POWER PLANT ENGINEERING

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Oakland Station of the Pacific Gas & Electric Co.

NEW 12,500-KW. ADDITION PLACED IN SERVICE EXACTLY ONE YEAR FROM THE TIME CONTRACT WAS PLACED. BY CHARLES W. GEIGER

IN JULY, 1908, because of the failure of certain sources of power upon which the Pacific Gas & Electric Co. had been relying, the officers and engineers of the company took into consideration the matter of erecting a 9000-kw. turbine plant in Oakland. After duly considering the question of choice between two types of turbines a 9000-kw. vertical Curtis turbine built by the General Electric Company was decided upon.

This decision was reached about the middle of July and orders were received by the engineering department to have the plant in operation in time to carry the Christmas load. The engineering department, therefore, had to undertake to design, construct and place in operation a complete turbine plant in 162 days.

The foregoing is a brief history of the plant, a new addition to which is described in this article. The construction requirements of this new addition, as regards time, it will be seen were very similar to those under which the original station was erected. The plant is known as Station C at Oakland and is located upon the Oakland Estuary.

THE NEW ADDITION TO STATION C

EARLY IN MARCH, 1920, it became apparent that there would be a serious shortage of hydroelectric power during the following summer. The winter had been unusually mild, and at the end of February the amount of snow on the ground in the mountains was only about one-third of that usually found at that time of year. It was, therefore, decided by the Pacific Gas & Electric

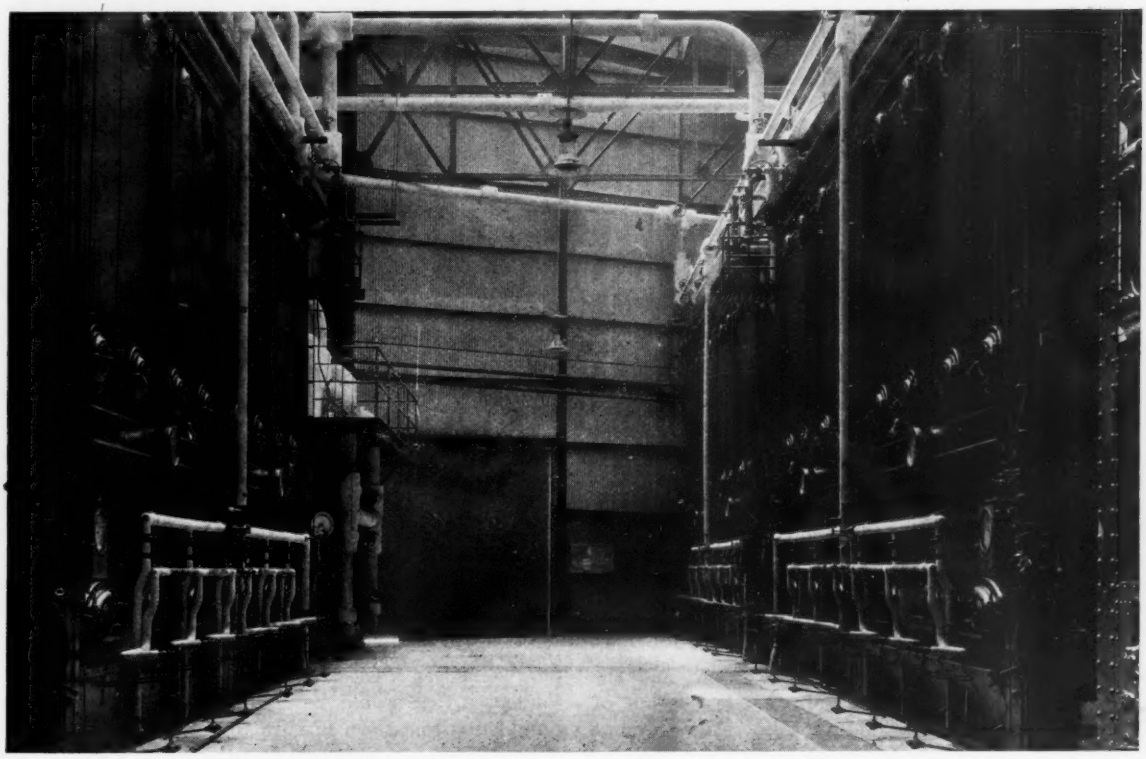


FIG. 1. VIEW IN THE BOILER ROOM OF STATION C, OAKLAND

Co. that an attempt should be made to install a steam turbine, either in one of the company's central plants or in a new plant at some location not then decided. It was felt that if prompt delivery of machinery could be obtained it would be possible to place a new unit in operation by the end of October, and if the rains of the following winter should turn out to be as late as they had been during the two preceding winters, this installation would be of assistance in tiding the company over until there was sufficient water in the stream to enable the hydroelectric plant to operate at full load.

It happened that at this particular time business all over the country was at its height—all factories were loaded down with orders—delivery was slow, and the congestion of freight was most serious. It was out of the question, under these conditions, to secure prompt delivery on a new order for a steam turbine, and the only solution was to secure a machine that had already been ordered for someone else and that might be available for purchase. The country was scoured for available turbines, boilers and condensers. It was found that the General Electric Co. had a 12,500-kw. turbo-generator going through the shop which would be ready for shipment in July, and which was available for purchase. This unit, therefore, was ordered on March 15, 1920.

It was also discovered that the Babcock & Wilcox Co. had an order for boilers for another purchaser that would be suitable to operate this turbine, and as this other purchaser could wait a few months it was possible to deflect these boilers to this company and order new boilers for the other purchaser. The six boilers were therefore ordered in March, with the promise that shipment would come through. The condenser for the unit was a stumbling block, as there appeared to be no condenser available that could be released from some other purchaser. The C. H. Wheeler Co., however, advised the Pacific Gas & Electric Co. that if they would order a condenser that would be a duplicate of the condenser purchased from them in 1918 for installation at Station A, San Francisco, it would be possible for them to make use of the patterns already on hand and by saving time in this way they believed that shipment could be made during July.

Up to this time the location of the plant had not been determined; consideration had been given to the building of an entirely new station at some location to be found that would be suitable so far as con-

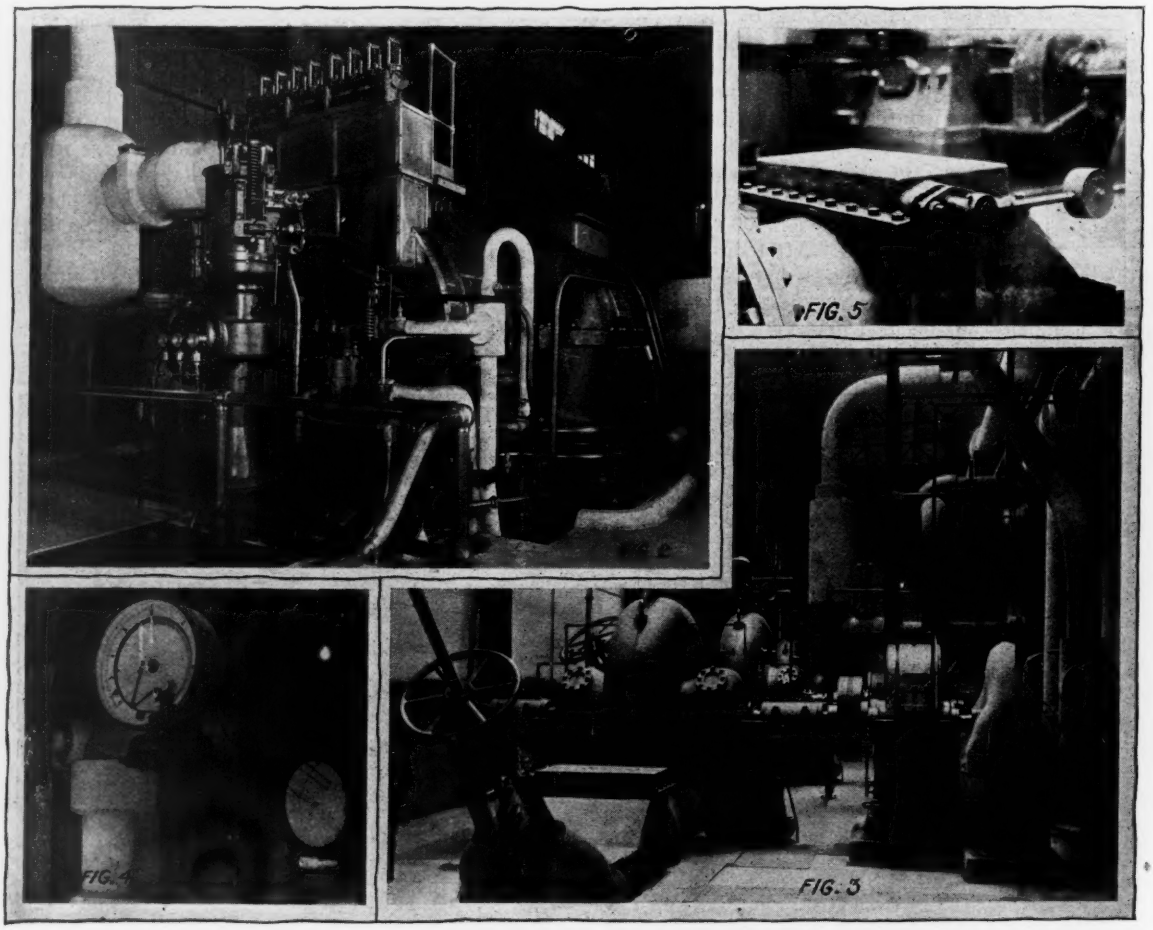


FIG. 2. THE NEW 12,500-KW. TURBO-GENERATOR. FIG. 3. THE NEW CIRCULATING PUMP, DRIVEN BY A 425-HP. TURBINE. FIG. 4. METERS FOR MEASURING FEED WATER AND ATOMIZING STEAM FOR THE NEW BOILER INSTALLATION. FIG. 5. SPECIALLY DESIGNED CHECK VALVE FOR CIRCULATING PUMP

densing water was concerned, and, at the same time, be conveniently located to the high tension line so that the energy from the new station could be readily transmitted to the entire system. Had a larger turbine been selected, it is possible that this would have been the ultimate solution. With the selection of a moderate sized turbine, however, it was at once apparent that the logical place for it was at Station C, Oakland. Here space was already available in the turbine room for a turbine of this size, a circulating water system of sufficient capacity to take care of this additional unit was already provided, and there was room on the property to erect a building extension in which to house the boilers; moreover it was found practicable to transmit the additional energy to the high tension line by running a new tie line to Station A at 23rd Ave. and installing additional transformers there.

It was estimated from the promises of deliveries of the main apparatus that it would be possible by working day and night to get the plant in condition to carry loads late in October or early in November, which would be in time to be of some assistance in tiding over the short water season if the rains were late in coming. The boilers were shipped on time. The turbine was about one month late, but unfortunately the condenser was badly delayed on account of the labor situation and was not shipped until late in November. In fact, the final carload of condenser equipment did not arrive at Station C until Dec. 31. Fortunately, the shortage of power was relieved by early heavy rains which occurred in October so that the delay in completing the installation did not affect the operation of the station. After the installation of the condenser, some large piping had to be connected up, the turbine had to be balanced up and the generator tried out. The turbine was finally placed on the line with a load on March 15, 1921, just one year after the order had been placed.

The turbine is a horizontal General Electric 12,500-kw. unit operating at 1800 r.p.m., direct connected to an a.c. generator, three-phase, 60-cycle, current at 12,000 v.

The condenser is designed to produce 28½ in. of vacuum, using salt water at a temperature of 60 deg. F. There are six M No. 30 Stirling boilers, built by the Babcock & Wilcox Co., rated at 823 hp. each, erected in three batteries of two boilers each. Each battery is provided with a steel smokestack 90 in. in diameter by 150 ft. high above the ground.

The boilers are provided with Leahy oil burners, capable of operating the boilers at 150 per cent of their rating. With this overload it is possible to carry full load on the turbine with only five boilers, so that one boiler can be shut down for cleaning and overhauling at any time. This makes the full capacity of the turbine available for the system at all times. The boilers are provided with large combustion chambers and with four-pass baffling which has been found in other installations of the Pacific Gas & Electric Co. to give excellent results. A feature of the design of this installation is the high steam pressure for which the machines are built, namely, 250 lb.; this is the highest pressure the Pacific Gas & Electric Co. has yet used at any of its plants, and with the high superheat of 150 deg. gives a total steam temperature of over 550 deg. F. which conforms to best modern engineering practice. A low exhaust temperature is obtained by the maintenance of a high vacuum in the condenser. With this pressure of 250 lb. it is possible to obtain about 4 per cent better efficiency of the turbine than with a pressure of 200 lb., such as is used in the other steam electric stations of the Pacific Gas & Electric Co. In addition to the main unit described above, the installation includes all auxiliary apparatus necessary for a complete power plant. The condenser auxiliaries include rado jets similar in all respects to the rado jets installed on the Wheeler condenser at Station A, San Francisco, and which have proven successful.

Circulating Pump

The circulating water pump was built by the Byron Jackson Iron Works of San Francisco and is driven through gears by a Westinghouse steam turbine of 400 hp. operating at 250 lb. steam pressure. As is well known, the use of reduction gears between the turbine and pumps make it possible to operate both pump and turbine at the most efficient speed. This circulating pump has a capacity of 30,000 gal. per min., and is connected into the main circulating system of the plant, which is already provided with one motor-driven and one engine-driven pump. The motor-driven pump has a capacity of 30,000 gal. per min. and is direct connected to a 400-hp. motor. The other steam-driven pump has a capacity of 35,000 gal. per min. and is direct connected to an American ball angle compound engine operating at 200 lb. steam pressure. These pumps have been provided with check valves, shown in Fig. 5, which were specially designed to go into the small space available. By the installation of these check valves the entire circulating water system is made more reliable and more

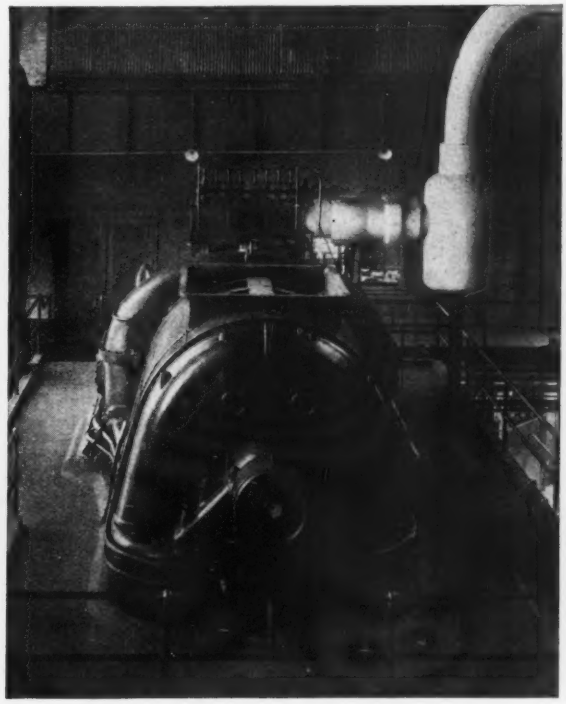


FIG. 6. VIEW OF NEW 12,500-KW. TURBO FROM GENERATOR END

flexible than it ever was before. For the purpose of priming these pumps there are two vacuum pumps of the two-cylinder type each geared to an individual electric motor. A large vacuum tank has been provided in the pump room for keeping a vacuum at all times. This tank was an old steam boiler which has been converted into a vacuum tank. This vacuum tank has pipe connections to the top of each pump; by opening a valve the vacuum draws the water up to the runners and the pump starts off without difficulty. By this means the pump can be primed in less than 30 sec.

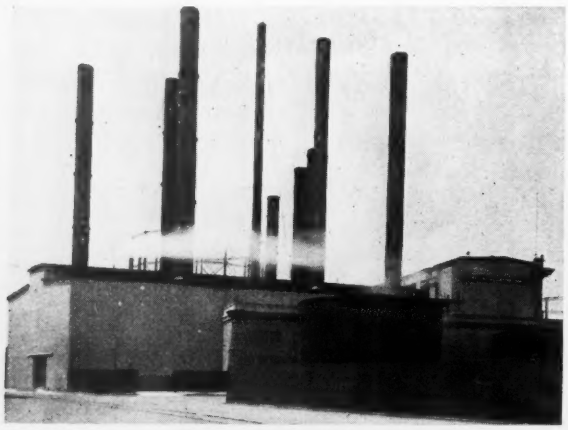


FIG. 7. OUTSIDE VIEW, STATION C, OAKLAND, SHOWING NEW BOILER ROOM ADDITION ON THE LEFT

An oil filter is provided to filter the lubricating oil for the new turbine. This is connected so as to pass a portion of the oil through the cylinder at all times, without in any way interfering with the circulation of the main body of oil through the turbine bearings. The generator is provided with an air washer to insure the cooling air for the generator being pure and clean. The two older turbines in this plant are also being equipped with air washers, and the three air washers are being connected together with a single pumping system for their water supply.

Fuel Oil

Fuel oil for this station is stored in tanks located across the street from the plant. These steel tanks are each surrounded by concrete walls which are capable of taking the contents of the tanks in case of a leak or other emergency. One of the tanks has a capacity of 20,000 bbl. of oil, the second tank a capacity of 6000 bbl., and the third 4000 bbl. The larger tank was moved from the old North Beach Gas Works, where it had been lying idle for a number of years. This tank was in excellent condition except for a few slight repairs that were necessary. By surrounding the tank with a concrete retaining wall of sufficient capacity to hold its entire contents in case of a leak, the surrounding property is protected. The oil is pumped into these tanks from the gas house of the Pacific Gas & Electric Co. 1400 ft. away, to which they are connected by means of two pipe lines, one 8 in. and the other 6 in. The oil is delivered to the gas house by means of tank steamers. A 6-in. pipe is laid from the oil tanks to the suction of the oil pumps; this pipe is carried in a concrete tunnel under the street with a concrete slab laid loosely over the top of it which, by lifting up, gives easy access to the pipe. There are four oil pumps of the duplex type, located in the fire room. After the oil leaves the pumps, it is heated to a temperature of 180 deg. by means of heaters equipped with steam coils. The exhaust steam from the oil pumps is used to heat the oil. This heated oil is delivered to the oil burners under a pressure of 70 lb. through a 4-in. pipe extending from the oil pumps to the oil burners and running in a concrete tunnel under the floor directly in front of the furnaces. The oil heaters are of the coil type, having external joints, so that any leak in the joint of the coils is immediately noticed and can be properly stopped. The oil passes through the inside of the coils at a high velocity so that a good heat transfer is obtainable.

The boiler room is steel frame covered with corrugated iron; skylights extend the entire length of the boiler room, providing excellent illumination during the day. There are 26 boilers at the present time, there having been 20 boilers previous to the recent installation. The boiler room is divided into two sections, one section having 10 boilers and the other 16 boilers and is well lighted at night by means of powerful electric lights with reflectors which are supported from the roof trusses. There are also gas lights for emergencies. In addition to providing steam for the operation of the turbine, the boiler room furnishes steam for heating throughout the downtown section of the City of Oakland. This downtown section is connected with the boiler room by means of a 10-in. pipe

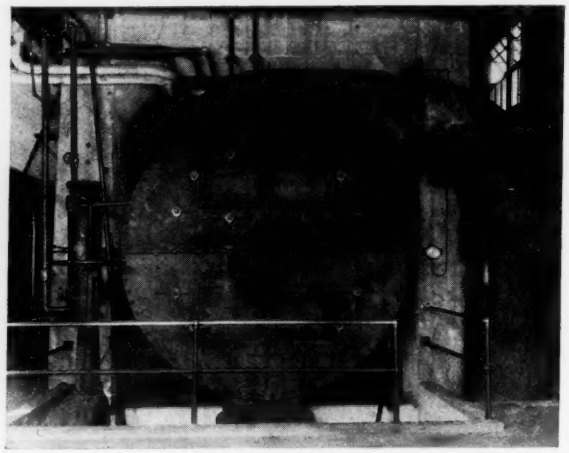


FIG. 8. THE NEW 25,000-SQ. FT. CONDENSER

heavily insulated and laid in concrete conduits with manholes placed two to a block. In connection with this steam heating system there are two reducing valves, one of which reduces the steam to 100 lb. pressure for summertime service, while the other reduces the steam to 125 lb. pressure for winter.

Water Supply

Water for the boilers is provided from two wells, owned by the company and connections are also made with the city main. One of the wells is located across the street from the main plant and is operated by an electrically driven pump. At this point there is a large steel water storage tank, the total storage capacity of which is 100,000 gal. Water is delivered to the make-up

tank by gravity. The latter is a concrete tank which is buried so that the top is level with the ground. The water is pumped from the make-up tank to the boiler feed water heater by four centrifugal pumps, three of which are driven by steam turbines and one by a motor. There are four feed water heaters, two being of the open type and two of the closed type. The open type heaters are of material assistance in purifying the feed water as the air and dissolved gases are driven out of the water when it is heated at atmospheric pressure, and, moreover, some of the floating matter is deposited in the heater instead of being carried on into the boilers. These heaters are provided with large storage compartments so that an ample supply of pure hot water is available at all times. The heaters are set on an elevated platform so as to give ample head to the feed pumps. The feed pumps are of the centrifugal type built by the A. S. Cameron Steam Pump Works and are driven by steam turbines.

A well selected meter installation under the care of M. E. Mulkey enables the operating men to secure maximum efficiency and aids them in keeping track of the performance of various units.

Each boiler is equipped with a Bailey flow meter which records the steam output of the boiler in per cent of boiler rating, the air flow to the furnace, and the temperature of the superheated steam.

On the feed-water line there is a Bailey flow meter of the type C-2; this meter is equipped with two recording pens and an integrator; one of the recording pens shows a continuous record of the water from the feed pump to the boiler, and serves to indicate how closely the water-tender regulates his valves on the feed line—the object always being to have this record as smooth as possible. On the same chart the second pen shows a continuous record of the feed water temperature. The integrating attachment works in conjunction with the mechanism which records the rate of flow of the feed water, and records the total flow of water fed into the boilers during any period of time. From this information it is possible to figure the evaporation per pound of fuel burnt. Another meter on the condensate line from the turbine shows at all times how much water is leaving the condensate line. From the record of this meter it is possible to determine the water rate of the turbine at all times, and it will show any defects that develop in the turbine to cause an increase in the water rate. On the steam line to the burners there is a General Electric flow-meter the indicating scale of which is visible for a great distance. The fireman as a consequence is always able to tell how much steam he is using to atomize his oil without having to walk up to the meter to read it. On the oil line to the burners there is a constant temperature control meter; this meter is set at a temperature at which it is desired to feed the oil to the burners, and by means of a thermostatic control this temperature is maintained.

The installation of the main unit and building foundations for the new installations was done by contract. The piping and the various auxiliaries were installed by the company's own men under the supervision of H. N. Mosher, East Bay Division superintendent of steam-electric generation. The building extension and the boiler and turbine foundation were designed by I. C. Steel, and the design of piping, and arrangement of auxiliaries was done in the company's own drafting room under the supervision of Henry Bosch.

Electrical Department

The electrical department of the power plant is housed in a separate building, called Station A, Oakland, this being located in the same block with the power plant.

Communication with the turbine room is had by means of special telephones. All switching and regulation is effected by remote control, centering in a bench board, which is located immediately in front of the special telephone booth. This equipment is shown in Fig. 10.

Current is fed into an 11,000-v. double bus from which the tie lines feed out to substations located in the Oakland district and through them tied into the transmission system.

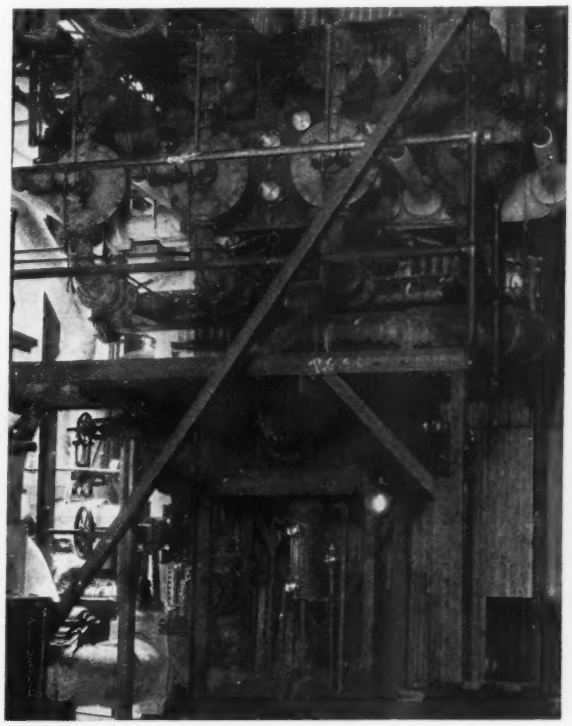


FIG. 9: THE RADOJETS AND AFTER CONDENSER, FOR REMOVING AIR FROM THE MAIN CONDENSER

For local lighting and power purposes the 11,000 v. are stepped down to 4000-v. service by means of two 6000-kv.a. 3-phase transformers, supplying current within a radius of 2½ mi. The various substations also step the 11,000 v. down to 4000 v. for local distribution, and transform up to 60,000 v. for transmission.

The main switchboard is 85 ft. in length and is made of ebony asbestos controlling 11,000 v., 4000 v. and 600 v. There are seven sets of 4000-v. single-phase regulators on the balcony of station A, which regulate the voltage on the 4000 v. distribution system.

The following apparatus is located on the main floor:

One motor driven exciter set consisting of one 4000-v., 3-phase motor and one 120-kw., 125-v. direct current generator.

One rotary converter, 6-phase, 500-v., three-wire, 850 kw., supplying direct current for neighborhood service. An 850-kw. motor generator set operates in conjunction with an 85-kw. balancer set when the rotary converter is shut down.

A 1000-kw. motor generator converts 11,000 a.c. to 600 v. d.c. for street railway service.

There are twenty-seven 4000-v. double switch cells back of the main switchboard and eighteen double switch cells for the 11,000-v. line.

Running the entire length of the building is an overhead crane of 20 tons capacity which is ample to handle the heavy equipment when making repairs, or overhauling.

The Load Dispatching System

In the operation of an electric system the problems first to be considered are those of continuity of service and regulation of voltage. With a system having but few sources of supply, these are comparatively simple, but as the number of generating stations and distribution lines are increased the problems become more complicated.

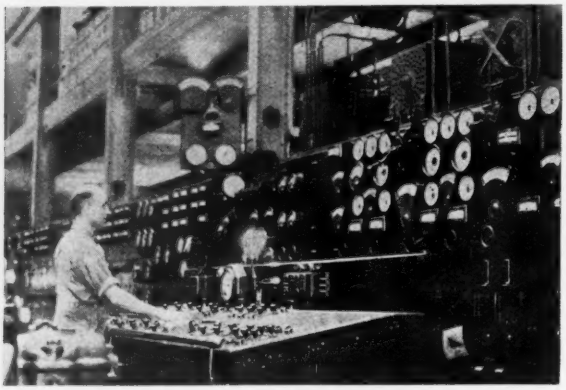


FIG. 10. BENCH BOARD AND INSTRUMENT SWITCHBOARD IN STATION A

The system of the Pacific Gas & Electric Co. is unique in that it has a greater mileage of high voltage lines receiving power from a larger number of sources than any other system in the world.

Not only do the twenty-four hydroelectric power houses of this company, aggregating an installed capacity of approximately 196,700 kw., all operate in parallel, but they are connected in with and receive power from many other power companies.

On first thought it would seem that the regulation and handling of load under these conditions would be a difficult matter. On the contrary, it is very simple. The present method of operation has been a gradual development. It was early found that in order to operate successfully under these conditions, two things were essential:

First. That so far as handling the load and regulation of voltage was concerned, there should be but one person in authority.

Second. That there should be a perfect telephone service between the principal power houses and the important switching stations.

The Bay Counties Power Co. was the nucleus of the present system and for several years Colgate was considered the master plant. From that point was handled not only the speed and voltage regulation, but also the line switching of the entire system. The arrangement continued in effect until the extension of lines brought the important center of switching near Davis, and for a time the operators at that place, acting with Colgate, handled the work which had formerly been controlled entirely from Colgate.

With the taking over of the Standard Electric Co. and the operation of that system in parallel with the Bay Counties system, it became necessary to control the two systems from some point, so far as possible common to the two. By virtue of its location, South Tower was elected as being the most suitable place, and from that point the load dispatching was handled until about 15 yr. ago, when it was found advisable to relieve the regular station operators of this responsibility and to create the position of load dispatcher. Thus the load dispatcher's office has come to be the center of operations of the entire system, from which the power house, switching station, etc., receives orders.

On the load dispatcher rests the responsibility of keeping the voltage normal and seeing that the fluctuations of load are properly taken care of among the different power houses. To do this requires not only a thorough knowledge of the power house conditions, but a knowledge of the character of the load on the system throughout the day, as this has a decided effect on the regulation of the lines.

A superintendent cannot take out of service a power house, transmission line, or any other part of the system which would affect the operation of the whole, without first receiving authority to do so from the load dispatcher's office. However, the division of load and regulation of voltage is by no means the most important part of the load dispatcher's duties; that of re-establishing service after an interruption, without unnecessary delay, is a far more difficult problem, and often calls for quicker and more decisive action. Operating as they do with everything running in together on a common network consisting of approximately 2500 mi. of line, trouble on any line will affect the entire system. At times of trouble the load dispatcher is busiest. It must be located quickly and the particular section of line on which the trouble occurs must be cut out.

Immediately after the operation of any high tension switch, either on a direct order from the load dispatcher's office, or during trouble when the regular routine tests are being made, such action is immediately reported to the dispatcher. In this office is located a board showing diagrammatically every generating station, transmission line, sub or switching station, also every switch in any of these different stations or on the lines. Stations and lines are represented by being painted on the board, but the switches are represented by dummies which can be adjusted to show the switch open or closed. The particular kind of switch, i. e., whether oil or air, is shown by the shape of the dummy.

The advantages of a board of this kind will be appreciated when one considers that there are in service on the entire system hundreds of air switches, the position of every one of which must be known by the load dispatcher.

When an order is given to operate a switch, no change is made on the board until the operator to whom the order is given reports that the order has been carried out, when the dummy switch is set accordingly. In this way a load dispatcher coming on watch can tell at a glance what lines are out of service and what switches are open or closed.

Thus will be seen the importance and necessity of reliable communication, particularly between the dispatcher's office and the principal switching points.

Telephone circuits are run on all high voltage transmission lines and ordinarily these give very satisfactory service. Often, however, they are of high resistance and not suitable for use over long distances on account of inductive troubles from the high voltage wires, which, during times of trouble on the transmission are great enough to make the telephone entirely inoperative. They are, therefore, used only for the local service on that particular section of line, the more important business being carried over a line leased from the Pacific Telephone and Telegraph Co.

In the dispatcher's office is kept a careful record of the energy delivered from the different generating stations, and daily load curves are plotted showing (a) the load generated at their own water power plants; (b) the load generated at their own steam plants; (c) power purchased, and (d) total load on system.

This information is completed between midnight and 8 a. m. for the 24 hr. ending at midnight, and shown in the form of a daily service report which reaches the general office by 8:30 each morning.

In addition to showing the load conditions, this service report gives the time and duration of interruptions to service at any substation, weather conditions, rain or snowfall, depth of snow at different gaging stations, depth of water in storage reservoirs, amount flowing in ditches or over diverting dams, and such other information as may be of interest and importance.

Turbine Efficiency Calculations

USE OF HEAT-ENTROPY DIAGRAM IN CALCULATION OF EFFICIENCY; ESTIMATING POWER LOAD TO MEET DEMANDS FOR EXHAUST STEAM. BY PAUL F. CHRISTOPHER

IT IS the purpose of this article to explain in a simple, non-technical manner a method for determining and comparing turbine efficiencies. An application of the principles given will simplify a number of power plant problems, give one a keener insight into the operating characteristics of a given turbine and will aid in the selection of machines which are suitable for various types of work.

There need be no fear of getting tangled up in a mass of complicated mathematics for by means of the accompanying chart, results sufficiently accurate for all practical purposes can be obtained by one or two simple calculations.

So much has been written on the subject of efficiency that a statement of the ground which will be covered by this article will, undoubtedly, be appreciated. In any case, efficiency is the ratio of output to input. Output is, of course, a perfectly definite amount of energy measurable in kilowatts at the switchboard, in pounds of water lifted, cubic feet of air displaced or what not. Input is an equally definite and measurable quantity though obtained in a different way. The steam delivered to a turbine contains an amount of energy depending on the pressure and temperature it has. Part of this energy is available for use in the turbine, but a certain amount is rejected to the exhaust. If the turbine under consideration were a perfect machine and could make use of all the energy available between its two working pressures the available energy could be determined by using thermometers and gages to find the amount of heat in the live steam at the throttle and subtracting from it the heat in the exhaust determined in the same way. In the case of an actual turbine, however, the available energy found in this way would be less than the actual available energy because the turbine is not able to use all of it and a part is rejected in the exhaust. Therefore, we are obliged to look for some other means of calculating the input and fortunately a simple method can be proposed.

To return to our definition of efficiency, a more concise expression for the relation mentioned above could be given as follows:

Rankine efficiency $= E_1 \div E_2$

E_1 = actual useful work performed.

E_2 = total available energy consumed.

This relation, which has been called Rankine efficiency, has a number of names any one of which is perfectly satisfactory, but for the sake of agreement with

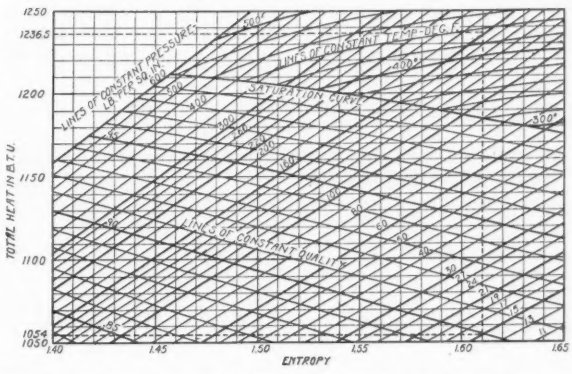


FIG. 1. SECTION OF HEAT-ENTROPY DIAGRAM FOR STEAM TO SHOW METHOD OF CALCULATING TURBINE EFFICIENCY

other writers who are trying to standardize technical terms, this terminology has been adopted.

The actual energy, output per brake horsepower-hour is $60 \times 33{,}000$ ft. lb. or $60 \times 33{,}000 \div 778 = 2545$ B.t.u. In the case of a turbine generator this would be multiplied by 1.34, giving a result of 3412 B.t.u. per kw.-hr. Thus $E_1 = 2545$ B.t.u. times the horsepower-hour output, or 3412 B.t.u. times the kilowatt-hour output, according to whether the unit of work under consideration is the horsepower or the kilowatt. The input of available energy, E_2, is the available energy per pound of steam multiplied by the pounds of steam consumed.

Available energy is conveniently determined by assuming that the steam expands adiabatically from initial pressure to exhaust pressure. This is in accordance with well established principles of turbine design and although adiabatic expansion is a theoretical thing which is probably never accomplished, yet it is the mark turbine builders are aiming at as it is the process which makes possible the most complete conversion of heat into energy. With a given amount of steam on hand ready to give up all its energy, we have to charge the turbine with the amount which could be obtained from such an expansion whether the turbine can actually extract it or not. This assumption is not only consistent with actual practice, but leads to a convenient method for determining available energy, as during adiabatic expansion the entropy of steam remains constant.

Anybody familiar with the principles of reciprocating engines will recall the equation PV^n = constant. This expression merely states the relations of pressure and volume under a given set of conditions. Entropy is another such expression which is derived from the relation of changes in pressure and volume to changes

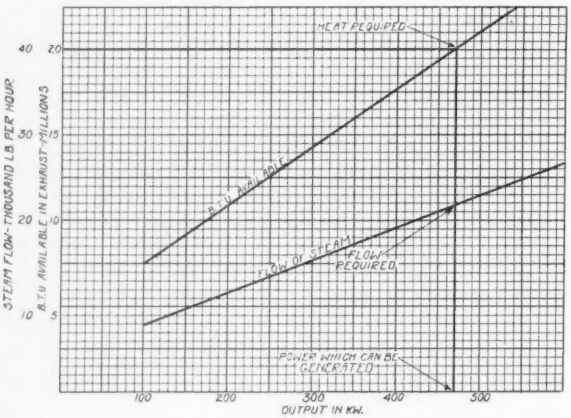


FIG. 2. DIAGRAM FOR ESTIMATING EXHAUST STEAM HEAT AVAILABLE AT VARIOUS LOADS ON A GIVEN TURBINE

in heat and temperature. Although somewhat mathematical in nature it may be used very successfully without going to the trouble of wading through a rather complicated explanation. It is sufficient to say that for every condition of steam there is a corresponding entropy and that during adiabatic expansion this entropy will remain constant in much the same way that PV^n maintains a constant value.

In order to make a concrete example of what has been said above, let us assume that we have a turbine designed to develop 400 hp. with initial steam pressure of 150 lb. gage, 70 deg. of superheat or an actual temperature of 435.9 deg. and atmospheric back pressure. The turbine has been guaranteed by the manufacturer to develop its rated capacity with steam consumption not exceeding 30 lb. per hp.-hr. By referring to the chart, we find that for the pressure and superheat specified, one pound of steam contains 1236.5 B.t.u. and has an entropy of 1.61. As we are assuming constant entropy, we proceed on the line corresponding to 1.61 entropy until it intersects the curve representing the exhaust pressure. At this point, one pound of steam contains 1054 B.t.u. As this is exhaust steam, this amount of energy would be rejected by the turbine if the expansion had been adiabatic and no other losses had taken place. The difference between the total energy and the energy rejected must be the energy available for doing work, thus

1236.5 B.t.u.
1054.0 B.t.u.

182.5 B.t.u. available per pound of steam.

$182.5 \times 30 = E_2$ = total input of energy per horsepower per hour. Rankine efficiency $= E_1 \div E_2 = 2545 \div (182.5 \times 30) = 46.5$ per cent.

At this point, some technically inclined reader may raise the objection that this discussion has not included the ideal engine operating on the Rankine cycle. It is true that no mention has been made of these relations, but they are included nevertheless. If we had an ideal turbine, adiabatic expansion would take place and available energy would be determined as just described. For every 2545 B.t.u. furnished, the perfect turbine would turn out one horsepower-hour; therefore, 2545 divided by the available energy, 182.5 B.t.u. in this case, would give the number of pounds of steam required to generate a horsepower for an hour. This equals 13.95 lb. of steam for the case we have just analyzed and this is the water rate of the ideal or theoretical machine. Another name for this quantity is the "theoretical water rate." The relation of the theoretical water rate to any actual water rate determines the efficiency of an actual machine as compared to a perfect machine. This checks out very satisfactorily as $13.95/30 = 46.5$ per cent as before.

In arriving at the efficiency of this turbine, we have used the water rate guaranteed by the manufacturer. In making water rate guarantees, it is standard commercial practice to promise a steam consumption slightly worse than that which it is actually expected to meet. This is due to the fact that tests vary a little, workmanship is subject to variation and local conditions often have unfavorable influences. Under these circumstances, a reliable manufacturer will make only guarantees which he is sure of meeting. Of course, methods vary; but in general, turbine designers take into account all known causes for loss of efficiency, and then, to cover unknown losses a flat addition is made to the calculated water rate.

If we suppose that the turbine we have been discussing is situated in a plant where exhaust steam can be utilized for heating or process work, it will be advantageous to know the quality of the exhaust. Upon request, the manufacturer will furnish a statement of the amount of steam which he actually expects the turbine will require. There may be some ambiguity connected with such statements, but a little clear thinking will straighten matters out. If a builder has promised that the steam consumption of his machine will not exceed so many pounds per hour and then says that he has used a margin of 3½ per cent, he means that he figures that his turbine will actually use 3½ per cent less than he has promised. On the other hand, a water rate guaranteed within a certain margin may be more or less than the figure stated, but the manufacturer really expects the machine will operate at the figure he mentions.

The margin in the case we have been considering may be taken as 6.5 per cent. Therefore, the actual

water rate will be $30 \div (106.5 \times 100)$ which equals 28.2 lb. per hp.-hr. The total flow of steam will be $28.2 \times 400 = 11{,}280$ lb. per hour. Assuming a friction load 2 per cent of the output, the actual water rate per horse-power-hour developed by the turbine wheels is $11{,}280 \div (400 \times 1.02) = 27.6$. This is known as the wheel water rate and the Rankine efficiency of the wheels will be given by the relation of the theoretical water rate. That is, $13.95 \div 27.6 = 50.5$ per cent, which means that 50.5 per cent of the available energy is absorbed by the turbine. This leads to the conclusion that the total energy less 50.5 per cent of the available energy will give us the energy, or heat remaining in the exhaust. A mathematical formulation of the above would read as follows:

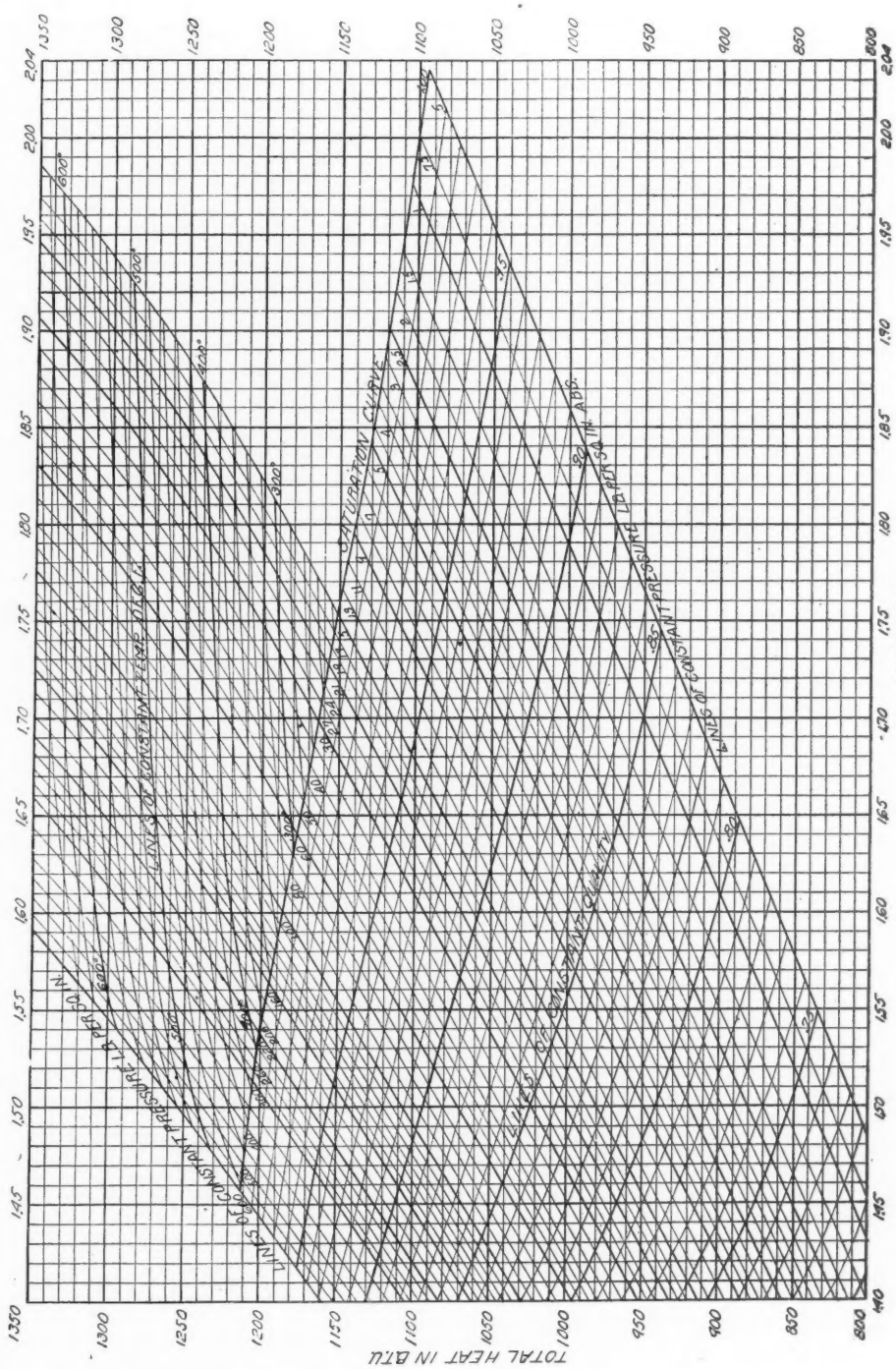


FIG. 3. HEAT ENTROPY DIAGRAM

$H - (H\text{-}H_a)$ Rankine efficiency = heat in exhaust.

H = total heat.

H_a = heat after adiabatic expansion.

Substituting in this expression the values previously found we have,

$1236.5 - (182.5 \times 0.505) = 1144.3$ B.t.u.

Referring to the chart, we find that steam containing 1144.3 B.t.u. at atmospheric pressure is 99.2 per cent dry. If the exhaust is condensed at this pressure, the heat available for process work will be the difference between 1144.3 and the heat of the liquid at this pressure. From steam tables, this is found to be 181 B.t.u. and the difference is 963.3 B.t.u., which is the heat available per pound of exhaust.

The same problem could be followed through for a generator set, but the explanation given above should make clear the use of the formulas which follow.

E_1 = 2545 B.t.u. when working with horsepower
= 3412 B.t.u. when working with kilowatts

$E_2 = H - H_a \times W.R.$

H = B.t.u. per lb. steam at initial pressure and temperature.

H_a = B.t.u. per lb. steam at exhaust pressure at constant entropy.

W.R. = manufacturer's guarantee, calculated water rate or actual water rate.

Theoretical water rate = E_1 (H-H_a)

Total flow of steam = W.R. × hp. or kw.

Wheel water rate = total flow ÷ wheel output.

Wheel output = actual output in hp. or kw. ÷ ($G_1 \times G_2 \times 0.98$)

G_1 = generator efficiency (omit if not a generator set)

G_2 = gear efficiency (omit if reduction gears are not used)

0.98 = mechanical efficiency of turbines. (This is an arbitrary constant and may be subject to some variation but for ordinary purposes is sufficiently accurate.)

Rankine efficiency of wheels = Theoretical water rate ÷ wheel W.R.

B.t.u. in exhaust = H-wheel Rankine efficiency (H-H_a)

Read quality for heat and pressure of exhaust from chart.

Available B.t.u. in exhaust = B.t.u. in exhaust — heat of the liquid.

Heat of the liquid is read from steam tables.

Turbine generators are usually guaranteed at three or four points, half load, three-quarters load, full load and sometimes load and a quarter. If a machine is a fairly large unit it will be designed so that it will have maximum efficiency under its normal load and consequently for other loads it will be less efficient. Smaller turbines are usually designed for greatest efficiency at full load. By determining efficiencies for various loads and plotting a curve on co-ordinates of efficiency and output, interesting observations can be made concerning the characteristics of a turbine.

An application of this method of analysis would be the determination of the energy obtainable from a given flow of heating or process steam. With expansion and growth, the power requirements of an industrial concern are bound to increase, and when the capacity of a power plant has been reached the only remedy is greater capacity. It then becomes a pertinent question as to what is the most economical way to furnish additional power. As a general thing, boiler capacity and power output go hand in hand and adding to one means an addition to the other. Therefore, if the capacity of a plant can be increased without a corresponding increase of boiler equipment, an appreciable amount of money can be saved.

Take, for example, an industrial plant which uses 20,000 lb. of low pressure steam for heating processes which is generated at 100 lb. gage and reduced through reducing valves to 2 lb. gage. From the chart we find that dry steam at 100 lb. gage contains 1189 B.t.u. per pound. This steam is condensed at 2 lb. gage and the heat available will be the difference between 1189 and 187, the heat of the liquid. The result, 1002 B.t.u. multiplied by 20,000 shows that 20,040,000 B.t.u. are required for the process work which is being carried on.

From whatever source seems most desirable, sufficient data is collected to permit the selection of a turbine which has steam consumption between the pressures specified, of about the same amount of steam as the amount required for heating. In this case a 500-kw. turbine which has the following characteristics is selected.

Kw. output	250	375	500
W.R.	54.0	48.5	45.8
Steam Flow	13500	18200	22900
Wheel kw.....	274	411	548
Theo. W.R.....	24.4	24.4	24.4
Wheel W.R.....	49.3	44.3	41.8
Wheel Eff.....	49.5	55.1	58.3
B.t.u. in Exh.....	933	925	920
Total B.t.u.....	12,600,000	16,830,000	21,050,000

The figures in the above table are calculated by the methods previously described and if carefully followed, the reader will have no difficulty in calculating values for similar problems.

From the table, a flow curve is now drawn on co-ordinates of flow and output. On the same axes, a curve of available B.t.u. is drawn on co-ordinates of flow and output. The method of drawing these curves is illustrated by Fig. 2. The second one of the curves just mentioned shows the B.t.u. in the exhaust available for heating at all loads on the turbine. Selecting on this curve a point where the exhaust steam contains 20,040,000 B.t.u. we find that this corresponds to a load of 470 kw. In order to carry this load the turbine requires 21,800 lb. of steam per hour, as is determined by dropping a vertical line to the flow curve. That is, by increasing the steam flow 1800 lb. per hour and using the turbine as a reducing valve an additional 470 kw. can be generated and the same amount of heat derived from the exhaust steam as was originally required.

THE BUREAU OF MINES, Washington, has recently completed a motion picture film showing the asbestos mines of the Johns-Manville Co. and the various factories and processes in the mining, refining and manufacture of asbestos into its numerous products, such as roofings, insulations, packings, brake linings, asbestos textiles, papers and asbestos woods and other products. The picture is available for presentation by clubs, engineering societies, Y. M. C. A.'s, etc.

IN 1920 the fire loss in the United States amounted to $500,000,000. Fifteen thousand people lost their lives on account of fire. Sixty thousand others were maimed by flames. And all this loss in face of the fact that buildings can be built that won't burn.

Recovery of Unburned Fuel from Boiler Furnace Refuse

By Thomas Fraser and H. F. Yancey

About 24 per cent of our total production of bituminous coal is used in industrial power plants. As regards fuel conservation, therefore, the recovery of unburned fuel from furnace refuse presents interesting possibilities. Considerable attention has been given to this problem in the past, but because of the comparatively low initial cost of power plant fuel in the pre-war period little progress has been made in this direction in the United States. Because of the higher price of coal in Europe more attention has there been given to the problem. In Germany, a process has been developed for separating unburned coal in refuse by using an electromagnetic separator.

In the United States, the use of mechanical stokers enabled low-priced screenings of high ash content to be used, so that even with relatively high percentages of combustible material remaining in the refuse, the loss in money is not excessive. If the price of screenings returns to the pre-war level around $1 a ton, the process proposed here will probably not be especially interesting, except where the freight charges are very high. If, however, the price of delivered coal continues high, such a process should result in considerable saving. The cost of continuous operation of such a refuse treating plant should not exceed 75 cents per ton of fuel recovered.

There are given below some results obtained by washing on concentrating tables the boiler furnace refuse from a well-operated, chain-grate stoker plant. The amount of unburned fuel present in boiler furnace refuse will necessarily vary widely in different plants, and would of course determine whether such a process is applicable to a particular plant operation. These tests were made on refuse from a very well equipped and efficiently operated power plant. At many plants, especially plants which are operated under excessive overloads, the percentage of recoverable fuel in the refuse is greater than in the material used for these tests. In any case it is believed that the recovery of unburned fuel from boiler furnace refuse by the use of concentrating tables would pay only in large plants. Considering the present freight rates, the advantages in the saving of transportation charges on fuel recovered at the plant is obvious.

Washing tests made in the laboratory of the mining department of the University of Illinois show the possibility of recovering the unburned fuel by crushing the refuse to ⅜-in. ring size, washing on coal-washing tables, and removing the slime from the washed product by a dewatering conveyor-elevator or a screen.

The coal-washing table is a standard piece of coal-washery equipment similar to the concentrating table commonly used in ore-dressing plants. It is essentially a linoleum-covered plane table, 8 ft. wide by 16 ft. long, supported in a horizontal position with an adjustable transverse inclination. An eccentric head motion at one end gives the table a longitudinal reciprocating motion of 235 to 265 strokes per minute. The raw material, with a stream of water, is fed on uniformly at the corner formed by the head-motion end and the high side of the table. The material spreads out on the linoleum surface of the table, and, due to the juggling motion, becomes stratified, with the light material on top and the heavy refuse next to the surface of the deck. The light material, which in furnace refuse washing is coal or coke, is carried over the low side of the table by the flow of water.

In addition to the water that goes on the table with the feed, some clear wash water is added continually all along the high side of the deck by means of a distributing launder. This is to help wash the light material over the washed-coal discharge side. The heavy material, which is largely cinder, is prevented from washing down across the slightly inclined surface by low wooden cleats or riffles tacked to the linoleum and extending lengthwise of the table. The reciprocating motion of the table, which has a slow forward stroke and a quick jerk back toward the head-motion end, works the discard toward the end, where it drops into a launder separate from the cleaned fuel discharging from the side of the table.

Results of two of the washing tests are given in the following tables. One of these tests was made using ⅜-in. mesh screenings from the general sample, and the other was made on the oversize crushed to pass a ¼-in. round-hole screen.

WASHING TEST ON ⅜-IN. SCREENINGS FROM BOILER FURNACE REFUSE

	Weight, pounds	Per cent of feed	Per cent ash
Raw material feed to table	215	100.0	57.8
No. 1 (washed fuel)	38	18.0	24.4
No. 2 (washed fuel)	11	5.2	28.7
No. 1 and No. 2 combined	49	23.2	25.5
No. 3 (reserved)	18	8.5	26.3
No. 4 (discard)	127	58.5	72.5
Sludge (by difference)	21	9.8	64.1

(Calorific value of washed fuel, 9730 B.t.u.)

WASHING TEST ON ¼-IN. OVERSIZE

	Weight, pounds	Per cent of feed	Per cent ash
Raw material fed to table	402	100.0	65.9
Washed fuel	72	18.0	26.7
Discard	261	65.0	78.0
Sludge (by difference)	68	17.0	51.8

(Calorific value of washed fuel, 9778 B.t.u.)

Combining the results of these two tests gives the average results for the entire sample of refuse as received from the power house. The total combined yield of washed fuel was 20 per cent of the gross weight of refuse treated. The washed fuels had an ash content of 25.5 per cent, and an average calorific value of 9754 B.t.u. The heating value of the dry screenings ordinarily fired at the plant is about 10,000 to 11,000 B.t.u., and the ash content 18 to 22 per cent. At a great many plants the boiler furnace refuse contains a larger percentage of recoverable fuel.

Operation of a table washery on a refuse such as is produced at this plant would result in the production of one ton of fuel from each 5 t. of refuse handled. A

one-table plant which would handle 6 to 8 t. of raw coal per hour will treat 5 t. per hour of boiler furnace refuse producing 1 t. of fuel per hour. Continuous operation of a one-table unit would therefore be possible at a power plant producing 120 t. of refuse per 24 hr.

The equipment required for a simple plant of this size consists of a corrugated roll crusher to which the refuse is fed by a chute direct from the power plant. The crusher should be set to crush the refuse to about ⅜-in. maximum size. The crushed material is stored temporarily in a feeder hopper of about 5 t. capacity, from which it is fed to a washing table by a short screw conveyor. Two inclined dewatering drag conveyors elevate the recovered washed fuel and also the discard from collecting sumps to their respective storage bins, and at the same time remove the water and fine slime. If water is scarce or costly, the overflow from the sumps may be clarified in a sludge settling tank or a thickener and returned to the system. The table feed, coming direct from the crusher, will contain a small percentage of oversize; however, in a plant of this size, the loss of oversize coke with the discard would not be sufficient to justify the installation of a screen and an elevator for returning the oversize to the crusher. This, however, should be considered at a large plant where several tables are required.

Dewatering of the washed fuel, as described, is essential because a considerable proportion of very fine ash washes over the table with the coke, and the removal of this slime will ordinarily result in a reduction of several per cent in the ash content of the recovered fuel.

In addition to reclaiming the combustible lost in the refuse, this treatment cleans the cinder and makes it more suitable for use as road material, concrete, or other construction work and reduces it to a more uniform fine size which facilitates conveying in pipes by steam or water pressure.

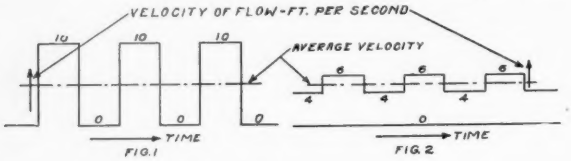
Operation of such a plant would require only a part of the time of one man, as a coal-washing table requires only occasional attention after it is started and properly adjusted. In most cases the freight charges on coal purchased to replace this recoverable unburned fuel would be more than sufficient to cover the cost of operation.—U. S. Bureau of Mines, Reports of Investigations.

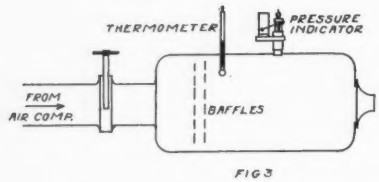
Use of Nozzles for Measuring Flow

Methods of Reducing Fluctuations in Flow to and From Air Compressors and Steam Engines. By W. Trinks

NOZZLES are one of the most valuable pieces of equipment in measuring the flow of fluids. Their application in the measuring of steady flow is well known and needs no further mention here.

When nozzles and some sort of measuring device for differential pressure are used for pulsating flow, errors result, unless the flow curve is known as a function of time. This fact is easily illustrated by reference to Fig. 1, which represents flow of fluid plotted against time. In this special case, it is assumed that the velocity of flow fluctuates periodically and abruptly between the values of 10 ft. per sec. and zero. Evidently, the average velocity must equal 5 ft. per sec. If, however, the velocity is measured by an instrument such as a nozzle, or a Venturi meter, or a Pitot tube in conjunction with a differential pressure gage, the instrument will not measure the average velocity directly, but its readings will fluctuate between 10^2 and 0^2, i.e., the readings will fluctuate between 100 and 0. If now the gage be throttled down so that it can be read, then it will show the average between 100 and 0 or 50; but the square root of 50 does not equal 5, but equals a little more than 7, and the conclusion is that this instrument will show 7 ft. per sec. instead of the actual average velocity of 5 ft. per sec.





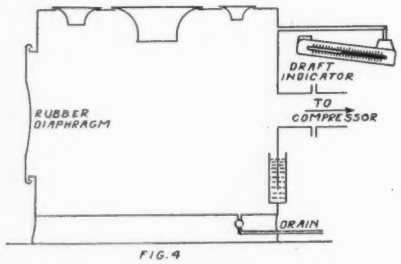


FIG. 1. PULSATING FLOW OF FLUID PLOTTED AGAINST TIME

FIG. 2. PULSATING FLOW VARYING BETWEEN 4 AND 6 FT. PER. SEC.

FIG. 3. TANK USED TO REDUCE FLUCTUATIONS IN AIR FLOW

FIG. 4. USE OF NOZZLES AND RUBBER DIAPHRAGM ON AIR COMPRESSOR SUCTION

This in itself would do no harm if we knew beforehand how much the excess reading is, but as stated before, to that end we must know the flow curve. Let the flow curve be as in Fig. 2, which again represents velocity of flow plotted against time and let the velocity fluctuate now only between 6 ft. per sec. and 4 ft. per sec., then the readings of the instrument will fluctuate between 36 and 16, these being the squares of 6 and 4. The average between 36 and 16 equals 26 and the square root of 26 is but little more than 5, from which it can readily be seen that the error becomes quite small if the violence of the fluctuations of flow can be decreased or damped. Several means can be employed for accomplishing this result.

In the testing or in the regular supervision of the air delivery of reciprocating compressors, it is quite possible to install a large tank between the compressor and the delivery line. This tank may well act as an

after cooler for removing the moisture from the air. If this tank be about three or four times the volume of the high pressure cylinder, the flow fluctuations are greatly reduced, and if, in addition, a throttling flange be applied at the end of the tank, i.e., at the place where the tank joins the delivery pipe, then the flow in the delivery pipe will be made quite even and a nozzle or a similar instrument can be used with great accuracy.

The larger the tank, the more uniform is the flow, and the smaller the throttling flange, the more uniform is the flow. The flange need not be so small as to produce any noticeable pressure drop.

The same method can also be used in the application of steam meters to measure the flow of steam for reciprocating engines. Every engine should be equipped with a large receiver separator and can, in addition, be equipped with a throttle flange at the place where the steam main joins the receiver separator. The flow is made even enough to apply a steam meter and to accept its readings without any correction.

There is a rumor afloat that the flow in lines carrying variable velocity fluids can be made even for a distance by placing a fan in the line at either side of the nozzle or of the measuring instrument, the theory being that the fans have inertia and resist pulsating flow, thereby reducing the violence of the pulsations.

In the testing of air compressors and blowing engines, or of Roots blowers, the following methods for the application of nozzles have been found quite successful. As shown in Fig 3, a valve may be placed in the discharge line from the air compressor or blowing engine, and a tank with the nozzle may be placed at the end of the line. The valve serves the purpose of varying the pressure against which the compressor discharges, and at the same time reduces the fluctuations of flow in the tank. The fluctuations proper can be measured by an indicator which is mounted on the tank and the drum of the gage is pulled as evenly as possible by hand. The indicator gives at once the average pressure in the tank and the fluctuations of pressure. The diameter of the nozzle and the pressure of the air in the tank together with its temperature immediately give the quantity of air flowing. Any corrections for variations in velocity can be made as indicated in Figs. 1 and 2. The baffles are necessary for eliminating the effects of velocity of approach upon the nozzle and should consist of perforated plates or strong wire mesh.

For the ordinary run of shop compressors, it is usually preferable to test the compressor while it is in operation. This can be done by using nozzles on the inlet side provided, of course, that the piston rod packings are tight. In this case, it is quite easy to secure uniform flow by attaching to the compressor inlet a sheet iron box which carries the nozzle or nozzles, and which, in addition, is equipped with a rubber diaphragm as shown in Fig. 4. The volume of the box acts as an equalizer and the rubber diaphragm which flops in and out helps materially to maintain an almost constant flow through the nozzles. A box of this sort is a very valuable adjunct to mechanical laboratories and especially in shops where air compressors are built or used, because it allows testing of the actual air compressor delivery with little trouble. To this end, it is advisable to have several nozzles in the box and to plug up those which are not in use. It is very desirable to have a safety valve on the box to protect the rubber diaphragm from injury in case someone should close more nozzles than is good for the rubber.

Such a safety valve is indicated on the right hand side of the box in the shape of a U tube full of water. The section of the U tube must be large enough to prevent the formation of such a vacuum in the box as might break the rubber diaphragm. The pressure drop of the nozzles can be kept quite small, and can be measured by means of an inclined gage such as a draft gage. The pressure drop through the nozzles amounts to much less than the variations in barometric pressure and no fear need exist that the measuring box will in any way interfere with the air delivery of the compressor.

Nozzles have not been used for testing to the extent which they deserve, probably for the reason that it is troublesome and expensive, first to lay out nozzles, and then to machine them. These obstacles, however, were removed some time ago by the Bacharach Industrial Instrument Co., which has standard nozzles for almost all purposes of testing. It may therefore be hoped that nozzles will be used more in the future for the testing of reciprocating machinery. It may also be stated that the discharge from positive blowers, such as the Roots or Connersville blowers, is likewise pulsating and needs some means for reducing the fluctuations.

Occasionally, it is practically impossible to damp the vibrations on account of the size of the equipment, for instance at the air inlet of blast furnace blowing engines. In that case the flow velocity curve can be determined occasionally by placing in the nozzle a very light flapper and by recording its motion on an indicator. In the use of such an instrument it is frequently found that, during very short intervals, the air actually blows back.

Fuel Value of Oil Shale

IN FEBRUARY, 1920, the State of Colorado and the United States Bureau of Mines entered into a co-operative agreement, relative to the oil produced from shale. The result is the compilation of Bulletin No. 1, entitled, "Short Papers from the Co-operative Oil Shale Laboratory," by Martin J. Gavin and Leslie H. Sharp.

Bulletin No. 1 consists of six short reports dealing with several subjects which are of interest to those engaged in any manner with the oil shale industry. The fuel values of oil shale and oil shale products are discussed in the first paper; the nature and composition of shale gas is presented in the second; the third gives production tables and curves for shale oil as obtained from the horizontal retort used in the co-operative laboratory at Boulder, Colo.; the analytical distillation of shale oil is taken up in the fourth; the fifth gives data on thermal calculations for the retorting of oil shales; the sixth is a tabulation of factors and formulas which have been found of value in the shale laboratory of the Bureau of Mines.

Copies of the bulletin may be obtained from United States Bureau of Mines, Boulder, Colo., or from the state oil inspector at Denver.

IF YOU cultivate your talents you'll always find an opportunity to use them. —Forbes Magazine.

Foreign Developments

AMONG THE MOST INTERESTING OF WHICH ARE THE THE USE OF VEGETABLE OILS AS COMBUSTIBLES IN SEMI-DIESEL ENGINES AND A LARGE TIDAL POWER PROJECT. BY J. H. BLAKEY

A NEW HANGAR for dirigibles has recently been built at Lucon, France, in the construction of which a new cement was used for the jointing of the reinforced concrete arch stones which form the elements of the framework of the great building. This cement, called "molten cement," having been in use for only a few years, is not generally known, and therefore it may be of interest to describe its remarkable properties and the various uses to which it is put.

The invention of this "molten cement" is the culmination of researches carried on in the laboratories of the Societe des Chaux et Ciments de Lafarge et du Teil, whose artificial double cooked cement is justly famous in France. It is obtained by the treatment of a product proceeding from the liquid fusion of a properly proportioned mixture of silica, aluminum, iron and lime. It is an extra-aluminous cement, of which the hydraulic properties are essentially due to the aluminates of lime of which it is composed: its hydraulic index is greater than unity.

At the Teil plant the mixture is melted in a water-jacket especially constructed for this purpose; next it is put into an electric furnace. On coming out of this the fused material, which is a vitreous mass of black color, is crushed and ground very fine. It is not even necessary to store it in a silo, as it contains no trace of free lime, and has never shown any signs of swelling. It is used much like ordinary Portland cement, but it is desirable to protect it very carefully against drying during the first few hours.

The particular quality which makes this cement different from others is its extreme rapidity of hardening. It is not an exaggeration to say that its resistance when used as a mortar is as great at the end of 24 hr. as that of the ordinary artificial cements at the end of a month. Hardness continues to increase with time, as is shown by the following laboratory tests, made with mortar ⅓ plastic.

	Resistance in pounds per square inch.				
Rupture by ...	1 day	2 days	3 days	7 days	28 days
Tension	413	484	491	505	536
Compression ...	5026	5585	5700	6612	6769

It is particularly recommended for use in reinforced concrete construction, as its rapid hardening and high resistance result in a considerable saving of material. It is also especially of value in constructions which must be completed between tides, as in the estuary of rivers or on a sea beach, and in general for all work which must be finished quickly.

It may be premature to say that it is not affected by sea water or by water containing sulphates, as this cement has been in use for only a few years; but experiments conducted in the laboratory since 1908 (the date of its invention) indicate its complete indifference to these destructive agents. The Compagnie de Chemin de Fer P. L. M., after a series of severe tests, made use of this cement in its subterranean work on the line between Nice and Coni, where the high proportion of anhydrite in the soil traversed made the use of any other cement impracticable.

VEGETABLE OILS AS COMBUSTIBLES FOR SEMI-DIESEL MOTORS

THE SOCIETE ANSALDO SAN GIORGO, of Genoa, has recently made a number of experiments for the purpose of testing the possibility of using vegetable oils as a substitute for the mineral oils which are now employed in semi-Diesel motors having an incandescent chamber. The tests were made on a single cylinder motor of 20 hp. running at 400 r.p.m.

The possibility of substituting a vegetable for a mineral oil is of interest to those regions in which mineral oil is scarce and costly, while certain vegetable oils are abundant and cheap. The comparative tests were made with a mineral oil of specific density 0.9, and with cotton seed and palm oils.

The characteristics of cotton seed oil are: color, yellow; limpidity, opalescent; density at 15 deg. C., 0.92; Engler viscosity at 20 deg. C., 19.64; flash point, 185 deg. C.; combustion point, 250 deg. C.; reaction, neutral; calorific power, 9573. The characteristics of palm oil are: color, yellow; density at 15 deg. C., 0.9; Engler viscosity at 50 deg. C., 3.5; flash point, 280 deg. C.; combustion point, 325 deg. C.; calorific power, 9350.

The results obtained in these three series of tests were as follows:

Oil	R.p.m.	Hp.	Consumption per hp. hr.
Mineral	405	23.5	260
	411	27.3	293
Cotton seed.....	412	22.8	299.1
	413	25.7	340.9
Palm	423	21.7	312
	395	24.0	328

The escape of gas was absolutely invisible with mineral oil, almost invisible with palm oil, but there were some traces of smoke with the cotton seed oil. The consumptions of the vegetable oils are a little greater than the mineral, but proportional to their calorific powers. The tests therefore are favorable to the use of vegetable oils in their regions of production, for motors of this type.

THE EFFECT OF COTTON FIBERS ON THE INSULATING POWER OF OILS

SINCE the year 1917, tests made at the Electro-Technical Laboratory at Tokio, Japan, by MM. Hirobe, Ogawa and Kubo, have indicated the very marked destructive effect produced upon the insulating power of the oils used in transformers by fibers of cotton or other rags used in cleaning the tanks containing the oil. The English Electrician, of March 2, 1917, expressed astonishment and perhaps incredulity at the results of these tests, which attributed to such a small matter as a few fibers the power of rendering almost ineffective the insulation of a transformer, and expressed the opinion that it would be necessary to check by new experiments the conclusions of the Japanese engineers.

These new tests have been made upon an enlarged scale, at the University College of Dublin, under the di-

rection of Professor McCleland, and in the Electrician of the 18th of March last, T. A. McLaughlin gives a detailed account of them, and draws the following conclusions:

The presence of a fiber is sufficient to enfeeble at a point in a mass of oil the specific resistance of the oil several hundred or several thousand times. There are thus set up in the insulation weak points which may bring about the rupture of the insulation and the destruction of the transformer; not only fibers but particles of dust or foreign matter can thus destroy the insulating power of the oil. It is almost impossible to clean the tanks with rags without leaving fibers which, although so small as to be invisible, may create a specific conductibility such as to form almost inevitably a region of decreased resistance favoring the passage of a current or of a spark.

The presence also of particles of water in the free state must be avoided, for if dust or fibers have been left in the tanks, the union of these elements can more easily constitute the chains of rupture. A fourth element comes in when a discharge occurs, resulting from the production of particles of carbon, which bring about almost infallibly the destruction of the transformer or at least of the insulation.

Utilization of the Tides for the Production of Power

For some months past, public opinion in England has been aroused, in consequence of a report of the ministry of transport, regarding a vast project for the utilization of the tides, which is being discussed in the technical journals and in the meetings of engineers. The recent coal strike and the increase in cost of fuel, is giving an impetus to the movement which is being watched with great interest in France, where plans have long been under consideration for the conversion of the power of the tides into electrical energy at a number of points on the coast which are contiguous to industrial regions.

For the purpose of economizing fuel, the English Board of Trade appointed in June, 1918, a commission of 15 members, under the name of the water power resources committee. While this commission was putting the last touches to its third report regarding the sources of energy, the utilization of which it considered practical, and especially the question of harnessing the tides in the estuary of the River Severn, the ministry of transport published, in November, 1920, its report on the same subject. The estuary of the Severn, on account of the depth and width (Figs. 1 and 2) creates between the region of Haverford West and South Wales a large maritime zone of separation which interferes greatly with important traffic between these two regions. To avoid for at least a part of this traffic, a detour by Gloucester which would add 50 mi. to the journey, the Severn tunnel has been built, but this is now too small to be of much value. At about 3 mi. above the tunnel (AB, Fig. 2) the crossing of the river could be made at Beachley, at a width much less, by means of a bridge; but a study of the sub-soil shows that it is unsuitable for the foundations of a bridge of large dimensions. In place of such a bridge, the ministry of transport proposes the building of a low level bridge on the line CD (Fig. 2), on the crest of a dam which will constitute the principal work necessary for the utilization of the energy of the tides in the river. It is estimated that such a project will give a quantity of electrical energy varying from 500,000 to 1,000,000 kw., according to the calculations of different engineers. In addition it will constitute a basin of locks having an area of 17,000 acres which would at all times be capable of harboring the largest vessels of the British navy. Just above this dam, at E, would be built the locks for the passage of ships, and this basin, furnished with docks, would allow of the building and repair of the largest ships. Electric locomotives would be used, and traffic across the bridge would proceed without interfering with river traffic by means of the loop CEF, which would be provided with

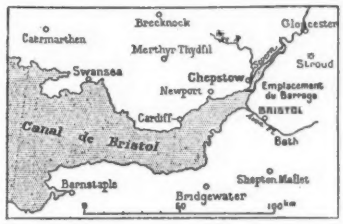


FIG. 1

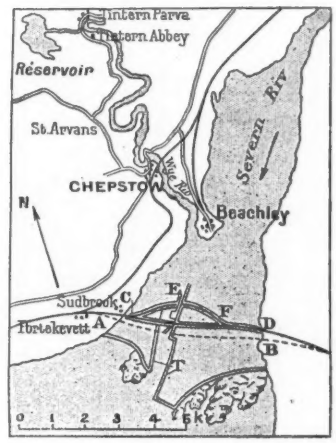


FIG. 2

FIG. 1. GENERAL PLAN OF TERRITORY SURROUNDING THE SEVERN

FIG. 2. PLAN SHOWING PROPOSED DAM ACROSS ESTUARY OF THE SEVERN

lift spans. The length of the dam CD would be about 13,000 ft. At first, the ministry of transport planned the installation of a plant which would utilize both the ebb and flow of the tides. This idea has been abandoned, and it has been decided to use only the ebb to drive the turbines, while the flow simply fills the reservoir formed by the dam. This method gives, of course, a double period in each 24 hr. in which no power is produced, unless special means are provided for this purpose. The hydraulic expert, A. J. Liversedge, has explained the regulation system to be used in a letter to the English "Engineer" of the 11th of March, 1920, and in the patent awarded him by the British patent office. This patent is No. 132,313, published Nov. 5, 1919, in the Abridgments of the Illustrated Official Journal of Patents.

The hydraulic turbines which would be driven by the backward flow of the water toward the sea, would be set up in a line of irregular form (Fig. 2) determined by the position of rocks in the estuary, and to reduce to a minimum the cost of crossing a zone of deep and rapid water called the "shoots." A part of the energy developed by the turbines would be used to drive the dynamos producing current for distribution; another part would drive pumps for raising water into an elevated reservoir C (Fig. 3) from which water would be drawn to drive the turbine E during the hours in which the water in the principal reservoir is insufficient. From the turbines E, the escape water would be sent into the principal reservoir.

The Liversedge patent includes, as a variant, the sending of the water in C into a hydraulic wheel H, mounted on the shaft of the principal turbine B. The pumps which fill the reservoir C are not shown in Fig. 3. It is evident that the principal turbine B will operate only during a part of the 24 hr., and that in that time it will be obliged to raise water enough to drive the dynamos during the remainder of the day, as well as to furnish current while it is running. This difficulty

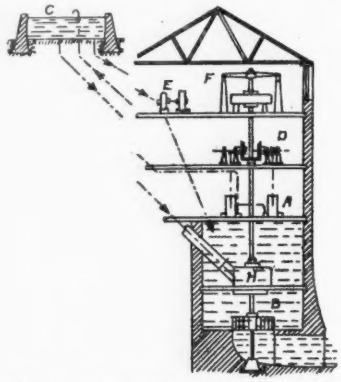


FIG. 3. SECTIONAL ELEVATION OF PROPOSED TIDAL POWER PLANT

is increased by the fact that the portion of the 24 hr. during which the water is sufficient to drive B varies from day to day, and from season to season. For the elevated reservoir C, the engineers propose to go up the River Wye to a point near Tintern Abbey, where a valley is to be found at a sufficient elevation and which could be easily closed by means of a dam. The tunnel connecting this reservoir with the turbines would have a diameter of about 50 ft. The turbines B are to be designed for a capacity of 1,000,000 hp., half of which is to be used for the production of electric power and the other half for pumping.

The amount of coal which would be saved annually, if the project is successful, is estimated at from 3 to 4 million tons. In addition there is to be considered the advantages accruing to the industrial region within range of power distribution. But the engineers are not under any misapprehension with regard to the difficulties to be overcome. For instance, the turbine would have to work under a difference of fall varying from about 16 in. to 28 ft., which is in the proportion of 1 to 21. Now the most modern turbines permit a variation of not more than 1 to 5, consequently it would be necessary to divide these periods into four different speeds, in order to assure the requisite r.p.m. for the alternators. With turbines 13 ft. in diameter a speed of from 40 to 80 r.p.m. is expected, and the dynamos will be driven from the vertical turbine shaft through reduction gearing. These will be direct current, on account of the varying speed; and this will be transformed into alternating current before distribution. The direct current will have a voltage of 525; the alternating current of 330; the transmission will be 60,000 v.

The cost of the whole installation is variously estimated at from 8,000,000 to 30,000,000 pounds sterling ($40,000,000 to $150,000,000). The first figure will bring the cost price of power to 1 cent per kilowatt-hour. R. A. Chattock estimates at 2,600,000 kw.-hr. for each day of 24 hr. the energy which will be furnished by the plant, which will have an efficiency of 63 per cent, and which will operate machines of a total power of 476,000 kw.

It is believed that the town of Birmingham, 50 mi. away, will consume 350,000,000 kw.-hr. annually, but it is thought that after taking into account all expenses the cost price will be not less than 2 cents per kw.

Expansion and Contraction

NOT LONG ago, four large chimneys were wrecked because they had become dangerous to life and property. Originally erected as steel stacks, they had been surrounded by reinforced concrete to strengthen and preserve the steel plate which had become badly weakened by corrosion. In adding the concrete, sufficient provision was not made for the expansion of the steel shell, with the result that after less than six years of service the stacks had to be pulled down.

We make provision for expansion in steam connections, for freezing of water in cylinders and pipes, and wherever necessary, and if we fail to do so trouble follows. Sometimes it is a difficult matter, as for example in the case of furnaces. In all these cases expansion and contraction are present and unavoidable, but we cannot get rid of them so we make provision for them.

On the other hand, there are our thermometers, expansion valves, shrink fits and many other useful applications of expansion and contraction. Without expansion and contraction we would lack a very useful property and many things we can do easily now could be done either not at all or with great difficulty.

It is an interesting fact that the cause of expansion and contraction which we all know to be change in temperature, is limited and it follows that we may usually place a probable limit upon the effects.

It may not be amiss to mention the expansion of the head, the expansion of the chest, and the contraction of the brow. These are a little different, but if we give them plenty of freedom they usually subside without doing damage. Probably the only exception to the broad statement that there is a "limit" is the contraction and expansion of the heart which may on the one hand descend to immeasurable meanness and on the other rise to immeasurable goodness and usefulness.

In nature, given the cause, the effect will follow. Often the effect is something we seek. Sometimes we do not wish it. In either case we must recognize it and provide for it.

Chart for Calculating Monthly Power Plant Costs

By A. R. Herske

IN MOST large industrial plants, the power superintendent is often called upon to estimate the monthly cost of operating the power plant with a certain specified production. This entails considerable calculations based upon suppositions and the result is no more satisfactory than that obtained by the use of the accompanying chart.

Taxes, insurance, and depreciation may also be considered as standby charges and be included in (3) and (4).

Once having determined these items, the accompanying chart accomplishes the following: in the upper right it shows the monthly coal cost in dollars for heating the plant to whatever temperature is desired; in the lower right it shows the monthly current cost in dollars for any production, adds these costs and to their sum adds the standby cost, consisting of direct labor, indirect material, taxes, insurance, and depreciation, and gives the approximate total monthly power plant cost.

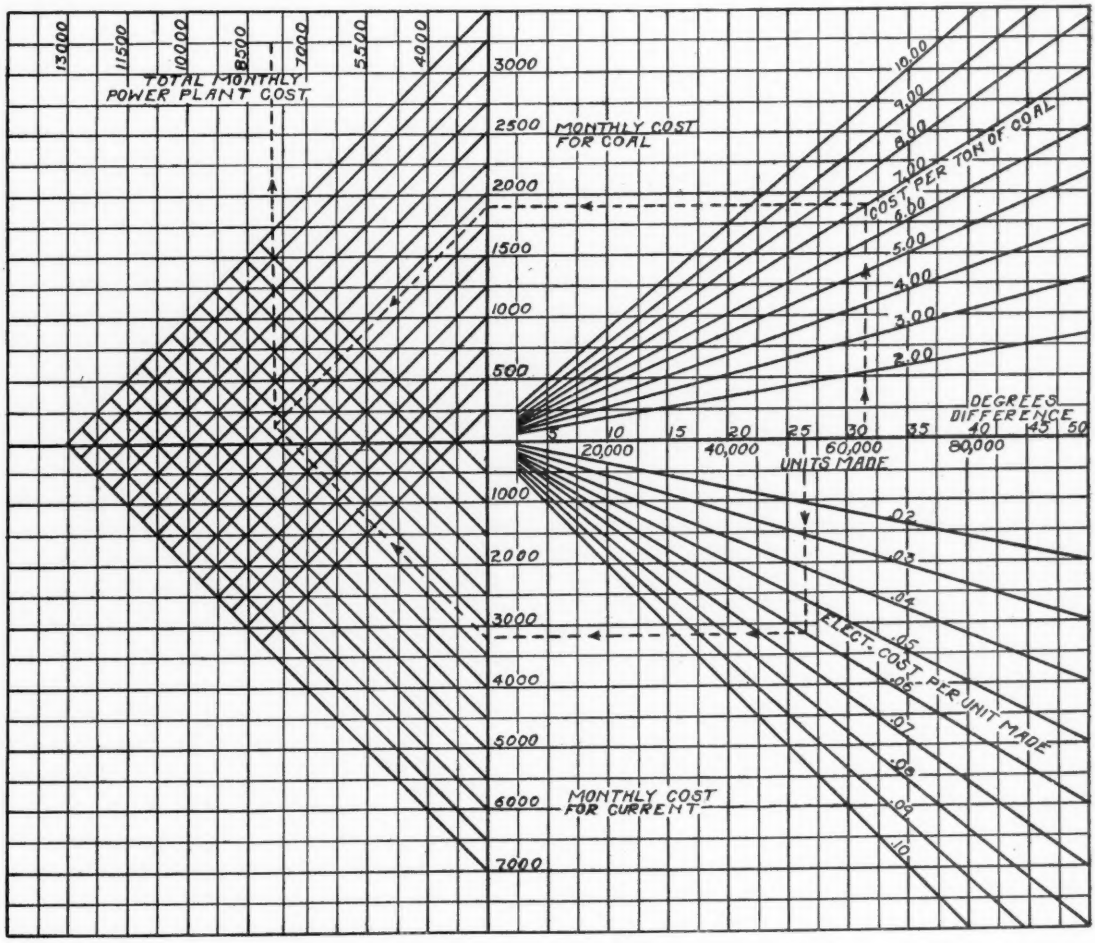


CHART FOR DETERMINING MONTHLY POWER PLANT COSTS

Figures should be available in all large plants showing the purchased current cost per manufactured unit produced, whatever that product may be, including current to motors and current used in manufacturing process; also the tons of coal required to heat the buildings for each degree of difference between inside and outside temperatures.

In the main, the total monthly power plant cost consists of four major items: (1) cost of coal, (2) cost of purchased current, (3) cost of direct labor, (4) cost of indirect material. The latter two items may be averaged over a certain period, and considered as a standby cost not materially affected through a large range of production changes.

The example worked out by the dotted lines shows that the monthly coal cost for a temperature difference of 33 deg., with coal at $7 per ton is $1900, based upon a coal consumption of 8.25 T. per degree difference of temperature to heat all the buildings.

Following from this point down the oblique lines to the intersection with the oblique line showing the current cost $3200 and then proceeding vertically upward, gives the total monthly cost $7600, including a standby cost of $2500.

Is it necessary for an engineer to be so immersed in his work that he becomes narrow and uninterested in humanity and its affairs?

Boiler Feed Water Treatment and Treatment Control*

CAUSES OF SCALE, CORROSION, FOAMING AND EMBRITTLEMENT. BY E. C. BASHORE

THE IMPORTANCE of water for chemistry, industry and science in general, simply illustrates what a remarkable compound it is. We often say without carbon no life. We could just as well say without water no life. Water is made up of two of the most important and swiftest ions, the H ion which is responsible for all of our acids, and the OH ion which is responsible for all our bases. This associated combination forming water, which at ordinary temperatures is assigned the formula $(H_2O)_4$.

The properties possessed by water may be said to be extreme and extraordinary properties. Take, for example, the contracting of water to 4 deg. C. and then expanding until it reaches the freezing point. If this condition did not exist, our globe would present a totally different appearance and fresh water life would soon be exterminated. Water is the best dissociant and possesses the highest dielectric constant of all more common liquids. Water is one of the most difficult of substances to prepare in absolute purity, the converse of which statement means that water is the best solvent of all liquids. It is this property of water to dissolve substances to an unusual degree that leads us to the main theme of our discussion, for thereby lies the necessity of purification for boiler feed purpose.

Water, whether it falls to earth as rain or snow, is never pure. Rain water contains dissolved or absorbed gases—carbon dioxide, oxygen, ammonia, and during thunder showers, nitric acid. Precipitated moisture either in the form of ground water or surface water accomplishes a marked erosive action on the earth's crust, both through mechanical weathering and chemical action. The result of the former type is shown by matter in suspension while the latter manifests itself through the dissolved impurities, and usually both processes occur simultaneously and mutually aid each other. By means of seeping water, easily soluble rocks, salts and minerals are dissolved as rock salt, potassium chloride, magnesium chloride, sodium carbonate, potassium carbonate, sodium sulphate, potassium sulphate and gypsum. Many rocks and minerals which are sparingly soluble in pure water are put into solution in large quantities through the action of water containing carbonic acid. Prominent in this class are the carbonates, calcite, dolomite, magnesite and spathic iron ore. Silicious rocks such as hornblende (containing silica hydrate, with aluminium oxide, magnesium oxide, calcium oxide, soda and usually some iron) may be decomposed by water containing carbon dioxide and certain component parts held in solution as bicarbonates of sodium, potassium, calcium, magnesium, etc.

Furthermore, water may be contaminated with free acid. Such pollution may be due to organic vegetable acids from swamps or bogs, acid discharge from industrial plants or often drainage from coal or ore mines, sulphuric acid being prevalent where the ores are sulphides.

* Abstract of paper read at the National Exposition of Chemical Industries.

The importance, then, that the nature of a boiler feed water bears to boiler operation may be made obvious by considering the quantity of water evaporated with its consequent residual products. For instance, in a 100-hp. boiler using water containing only seven grains of solids per gallon, over 300 lb. will be the quantity of solid matter for one month, while many spring waters would give over 2000 lb. of residual matter which must either be blown out or deposited.

Just as a physician must correctly diagnose a case from certain specific symptoms before he is in a position to administer corrective treatment, in the same sense a water treating engineer must analyze symptoms before applying remedies. The logical development of our subject, therefore, would behoove us to discuss the various troubles associated with waters of different characteristics prior to discussing the corrective measures to be taken.

As a result of the impurities that a feed water may carry, the following conditions are conventionally recognized in boiler practice, namely: Scale formation, corrosion, foaming or priming, and caustic embrittlement.

SCALE

SCALE FORMATION is due to the presence of carbonates, sulphates, sediment and mud, and to a slight degree soluble salts in the feed water and its deposition on the inside of the boilers not only lessens the available water space, but acts as a non-conductor of heat. Without being able to vouch for the authority, the estimate is made that 1/16 in. of scale causes a loss of 13 per cent of fuel, ¼ in., 38 per cent and ½ in., 60 per cent of fuel.

The scale forming carbonates in water are those of calcium and magnesium. Both are very sparingly soluble in pure water; the presence of carbonic acid in the water renders them soluble as bicarbonates; however, carbonic acid is insoluble in boiling water, and is liberated with a consequent partial precipitation of calcium and magnesium carbonates which tend to deposit as a soft scale similar to a chalk formation.

The sulphates which are scale forming are those of calcium and magnesium. Magnesium sulphate alone does not form a hard scale, but in the presence of calcium carbonate forms a very stony scale hard to remove. Calcium sulphate alone forms a hard tenacious scale similar to gypsum in character.

Sediment and mud also cause scale by depositing and baking on the fire sheet of a tubular boiler, the lower tubes in a water tube boiler and the crown sheet in a marine or locomotive boiler. Soluble salts can also be incorporated in the scale if the concentration is too great.

BOILER CORROSION

THE SECOND ailment which has been classified as a condition traceable to the composition of the raw feed water is corrosion. This is perhaps the most dangerous trouble associated with feed waters, and the responsible

agent should always be determined and corrective measures applied. Four causes of corrosion common to boiler practice may be mentioned, namely:

1. Free acidity in the feed water.
2. Substances which react under temperature and pressure so as to produce acidity.
3. Electrolysis.
4. Dissolved gases in the feed water.

Free acidity is common to waters which drain mining districts, particularly coal mining areas. A notorious example of this condition is that of the Youghiogheny River, which is acid practically all of the time and occasionally shows as much as twelve grains per gallon of free sulphuric acid. Free acidity may also be the result of industrial contamination, especially in localities where the nature of enterprise calls for considerable pickling, such as would be common in tin plate mills, wire mills or seamless tube mills.

Developed acidity within a boiler is perhaps the most common type of corrosion met with in power plant practice and magnesium chloride is frequently the responsible agent. Under the influence of temperature and pressure magnesium chloride is said to be dissociated into magnesium hydrate and hydrochloric acid, the latter free to attack the metal parts with consequent waste. Under certain conditions of temperature and pressure, waters relatively high in sodium chloride and silica may develop a corrosive action and the statement is made that magnesium sulphate in the presence of high organic matter will react so as to develop a corrosive attack.

Electrolysis is a condition which sometimes exists, and in this case the water is only indirectly responsible. Absolutely pure water is a non-conductor of current, and electrolysis therefore, may take place only because the water carries sufficient soluble salts to permit the conductance of stray or induced currents. Two types of electrolysis have been encountered, namely, galvanic action as the result of metals like copper and iron in intimate contact, and, stray currents the result of electrical force extraneous to the boiler proper. These two types of electrolysis may be illustrated by actual examples.

Galvanic action was observed in the drum of a boiler in which case the steel adjacent to the bronze composition feed and check valve was badly pitted and corroded. Evidently, electric current was generated at this junction point, and in the presence of salt water developed sufficient energy to drive the iron into solution. This citation does not necessarily condemn the use of bronze fittings in connection with boiler practice because local conditions probably promoted the galvanic action; however, that electrolysis was the active agent responsible for the corrosive attack was proved by the introduction of a zinc slab to divert the current from the steel to the zinc, after which the corrosion was stopped.

Electrolysis was suffered in a large power plant from a stray current. In this particular case a trolley return was grounded to the main water feed line leading to the boiler house. Without disturbing the ground wire connection, and by interposing an electrically insulated flange joint connection in the feed line the trouble with electrolysis in the boiler was at an end.

Since electrolysis does not respond to chemical treatment, and since corrective measures will not be referred to elsewhere, it might be well to mention the necessary steps to be taken in order to eliminate this kind of metal wastage. In cases of galvanic attack, zinc metal has been used successfully. With the introduction of zinc slabs into the drums of boilers where such a course is deemed necessary, care should be exercised that the zinc has perfect contact with the steel part of the boiler. From an engineering standpoint, where electrolysis is evident, the best procedure is to locate the source and either eliminate or divert it.

Gaseous corrosion is not of serious proportion or consequence in connection with boilers proper, but economizers may be affected to a marked degree. Water is capable of dissolving about 8 cu. cm. of oxygen per liter and appreciably more carbon dioxide. These two gases are the agents especially responsible for corrosive attack, and while some few scientists maintain that one gas alone is responsible to the exclusion of the other, it is probable that both gases under certain conditions are active agents and mutually aid each other in metal wastage.

One phase of the matter is important from the standpoint of magnesium chloride in the presence of water containing dissolved oxygen. As previously mentioned, magnesium chloride is very corrosive under the dissociating action of temperature and it so happens that comparatively a small initial amount may cause marked destructive action because in the presence of dissolved oxygen, the magnesium chloride may be regenerated, whereby the corrosive action works in a cycle.

Foaming and Priming

These two conditions are considered together because they both tend to cause wet steam; however, each may be the result of a totally different cause.

Foaming is largely a surface effect and is caused by certain types of organic matter, saponifiable oils in the presence of caustic soda or sodium carbonate and matter in suspension. On the other hand, priming may be defined as a condition whereby the steam is liberated in slugs as compared against even ebullition under normal conditions. The cause usually assigned for the effect is increased surface tension of the water as the result of concentration of the sodium salts. All sodium salts, being soluble, have a tendency to increase the surface tension of the water, thereby disturbing evenness of ebullition. In other words, when the concentration of sodium salts is high, on account of associated increased surface tension, the water tends to liberate its steam in slugs, the consequence of which is a spray which is carried over with the steam.

It is stated on authority that a boiler can usually stand twice the concentration of sodium chloride that it can of sodium sulphate or sodium carbonate. From the standpoint of priming, the design of the boiler is perhaps of more importance than the composition of the water, and in a general way, small drums and tubes inclined toward a vertical position have a tendency to aggravate priming.

Embrittlement of Boiler Metal

Caustic embrittlement is the fourth ailment to be discussed in connection with troubles associated with boiler feed water. This condition as related to boiler practice is of comparatively recent origin. It is prob-

able that a number of boiler failures in times past have been attributed to inherently defective metal when in reality the peculiar characteristics of the feed water was the responsible agent. Caustic embrittlement tentatively may be defined as that condition in boiler practice whereby local areas of the steel of the boiler become embrittled due to absorption of hydrogen gas which results from peculiar conditions of concentration of caustic soda within the boiler.

To bring about this action, it is not essential that caustic soda initially be present in the feed water as such, because under the influence of temperature and pressure both sodium carbonate and sodium bi-carbonate hydrolyze so as to form caustic soda. The evidence of steel becoming embrittled through feeding the boilers with water containing excessive amounts of free sodium bicarbonate (normal carbonate or caustic soda) is more inductive than it is capable of direct laboratory proof; however, the many cases which have come under observation in times past where caustic embrittlement has been suspected, have always been associated with either artesian well water abnormally high in free sodium bi-carbonate, or in plants where treatment with soda ash, caustic soda or boiler compound has been carried to excess.

In certain geographical districts of Illinois and Texas, boilers, irrespective of type or manufacture, are liable to cracked plates provided the feed water is supplied from artesian wells, and sodium bi-carbonate is the only unusual constituent of the well waters of these districts. Another pertinent example is the failure of the drum sheets in a torpedo boat destroyer boiler in which case the log sheet of the boat showed the use of several times the prescribed amount of compound containing soda ash as the base.

Like everything new, the idea of caustic embrittlement has not met with universal acceptance. Caustic embrittlement as it stands today, supported by strong inductive premises, is of sufficient importance to merit the most careful attention of all water treating engineers. This condition is undoubtedly the most insidious of all troubles encountered in feed water problems.

The theory of the mechanism of caustic embrittlement amounts to the belief that leaks occur in the seams of the boilers, and that these leaks permit the concentration of caustic soda in the seams of the boiler. It is definitely established that concentrated caustic in the presence of steel will develop free hydrogen gas, and the steel is susceptible of occluding hydrogen gas with a subsequent embrittling action.

While the importance of caustic embrittlement as a menace is not to be lost sight of, we would emphatically state that all water containing free caustic is not necessarily a dangerous water. The danger lies in excessive concentration and permitting leaks along the seams of boilers to go unchecked. On the other hand, both caustic soda and sodium carbonate have markedly beneficial effects from a scale and corrosion standpoint provided the quantity is held under definite chemical control.

Methods of Treatment

No absolute rule can be established for the treatment of all feed waters, nor can a "cure-all" or panacea be improvised because each feed water from a different source will necessitate a treatment peculiar to itself.

The function of chemical treatment of a boiler feed water is to minimize the existing evil. It must be remembered, however, that every chemical reaction calls for a by-product, and while possible through chemical treatment to correct one unfavorable condition, it is also possible to induce another. But, with intelligent operation, careful chemical control and reasonable cognizance of the principle involved, a great saving in coal, labor and wear and tear on the boiler invariably can be accomplished in industrial plants through the application of a properly advised treatment.

Generally speaking, there are six different methods of treatment, as follows:

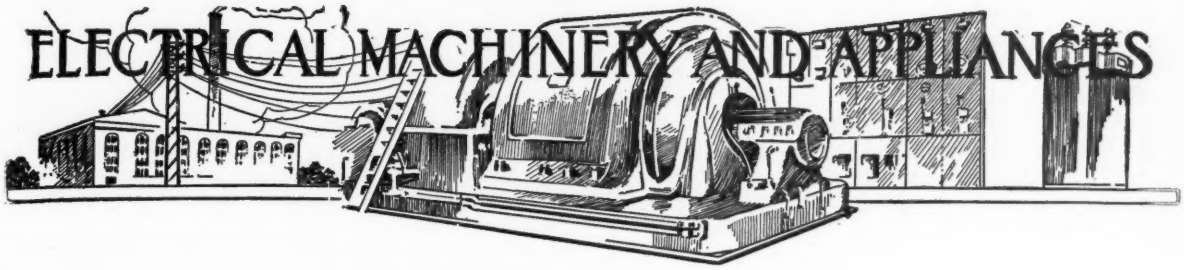
1. Boiler compounds.
2. Feed water heaters supplemented with chemical dosages.
3. Continuous tank systems.
4. Intermittent tank system.
5. Artificial or natural zeolite.
6. Internal treatment with commercial reagents in definite and predetermined quantities.

As previously stated, no such thing as a panacea for all boiler water difficulties exists, and while each method or purification scheme has inherent advantages, associated with the advantages are also corresponding disadvantages. Control is the crucial word which frequently spells success or failure. As summation, let it be stated that any properly advised chemical treatment of boiler feed waters will return large profits, as against the investment involved or the cost of treating chemicals provided the treatment is maintained under reasonable intelligent control.

Alarm Columns in Seward Plant

Through misinformation, in the list of apparatus installed in the Seward power plant published on page 946 of the Oct. 1 issue, the Williams Gauge Co. was credited with furnishing two Stets feed pump governors. This was incorrect, but this company did furnish high and low alarm columns and Stets controllers to the Seward plant, no mention of which was made in the list of equipment.

U. S. Civil Service Commission announces an examination (receipt of applications to close Nov. 15) for associate electrical engineer to fill vacancies in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa., at $3000 to $4000 a year, and in positions requiring similar qualifications at these or higher or lower salaries. The minimum requirements for eligibility are as follows: Graduation in electrical engineering from a college or university of recognized standing, or a specified equivalent; and at least 5 yr. subsequent electrical experience, of which not less than 1 yr. must have been in the inspection, installation, and maintenance of electrical equipment used in mines, and not less than 1 yr. in the laboratory investigation and research of electrical apparatus. Applicants must not have reached their seventieth birthday on the date of the examination. Apply for Form 2118, stating examination title.



Lightning Arresters---I

A Discussion of the Operating Characteristics of Various Types of Lightning Arresters and Considerations Which Govern Their Selection. By V. E. Johnson

IT IS not the purpose of this article to discuss the theory of the various classes of electrical disturbances against which lightning arresters serve as protection. Neither is it concerned with the design of arresters nor with the mathematics of the subject.

The engineer in many plants performs the functions of line superintendent and is frequently called upon to select protective equipment involving a considerable outlay of money. It is with the thought of providing him, under such conditions, with a standard on which to base his judgment, that this is written.

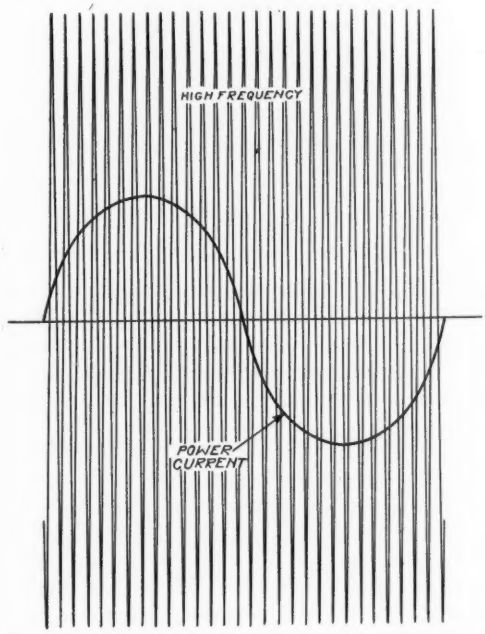


FIG. 1. OSCILLOGRAPHIC DIAGRAM ILLUSTRATING IN A SMALL MEASURE THE DIFFERENCE BETWEEN A HIGH FREQUENCY CURRENT AND A POWER CURRENT

Lightning is a high frequency discharge between clouds or between the clouds and the earth. It differs from ordinary power current in at least two particulars: (1) The waves or periods are very short; (2) their amplitude is very great. It is assumed that the frequency of a lightning discharge is sometimes 1,000,000 cycles per second, while the voltage reaches inconceivable values.

No lightning arrester can withstand a direct stroke, and protection against such conditions is not the intention. A direct stroke on the line breaks down the insulators and reaches ground without traveling very far. It is no uncommon occurrence to find a direct stroke destroying insulators and yet discharging very little over arresters one or two spans away.

The disturbance which arresters protect against is that induced in the line by discharges in its vicinity—either between clouds, or to the ground. The total amount of energy involved in such an induced disturbance is comparatively small, but the rate is so high as to make it almost explosive in character.

The frequency of an induced stroke is at its beginning as high as the primary discharge—perhaps a million cycles, but due to the inductance of the conductors, this is reduced to perhaps ½ that value. Engineers agree pretty well that arresters are seldom if ever called upon to handle a discharge of over 500,000 cycles. The

FIG. 3. SAFETY SPARK GAP FOR PROTECTION OF TRANSFORMER WINDINGS

voltage may at the point of generation rise to a value sufficient to spill over the insulators, and so dissipate its violence, or it may travel long distances to an arrester. Obviously the voltage will be reduced by this long travel, as will be the energy.

High frequency disturbances are also set up in large systems by various internal conditions. For example opening a heavily loaded oil switch will create a disturbance approximating in milder form that of a lightning stroke. Similarly an arc between a line and ground, even though of very short duration, will under favorable conditions, set up voltage surges that may, and often do, damage connected electrical apparatus.

Characteristics of High Frequency Current

It is practically impossible to show in their true relation an ordinary power voltage curve and a high frequency curve because of the great difference, but Fig. 1 shows in some measure the contrast between them.

If the reader can now imagine the effect of putting say 1000 times as many waves as are shown in this sketch, and making them, instead of twice as high as the

sine wave power current, say 500 times as high, he will have a mental picture of what high voltage high frequency disturbances really mean.

We are familiar with the fact that among other things the voltage induced in a coil of wire by a magnetic flux is proportional to the rate of change of that flux. In commercial transformers 60 cycles is a standard frequency, and they are so designed that at this relatively low rate of change the voltages are of the desired values. Imagine now a magnetic flux collapsing at a rate commensurate with the steepness of the lines in a figure, such as shown, magnified several hundred times, and it can be seen that the voltage induced would be terrific. Even if the high frequency voltage impressed on a circuit were no greater than the power voltage, there would still be induced dangerous potentials due to the very high rate of change of flux.

In other words, a high frequency discharge, even though its maximum initial voltage be low, will induce in the circuits with which it comes into contact dangerous rises of potential. In a transformer, for example, it is very common for the voltage induced to become so high that the coils break down between turns. To protect against such damage, the end turns in commercial transformers are more heavily insulated than the remainder of the coil, and in installations of importance the end coils are in a sense placed outside of the transformer proper—in the form of "choke coils." It is cheaper to insulate choke coils against breakdown than it is to embody the insulation in the structure of the apparatus itself.

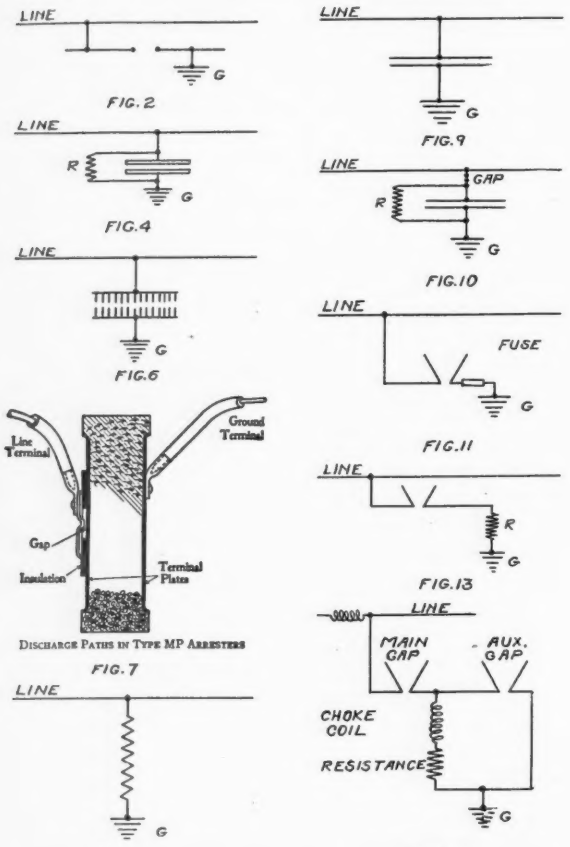


FIG. 2. SIMPLE SPARK GAP AS A FORM OF ARRESTER
FIG. 4. SPARK GAP FOR A.C. VOLTAGES UNDER 350
FIG. 6. MODIFIED FORM OF SPARK GAP IN WHICH A NUMBER OF PARALLEL PATHS CARRY OFF THE DISTURBANCE
FIG. 7. COMMERCIAL FORM OF ARRESTER SHOWN IN FIG. 6
FIG. 8. DIAGRAM OF RESISTANCE ARRESTER
FIG. 9. CONDENSER TYPE ARRESTER
FIG. 10. MODIFICATION OF ARRESTER SHOWN IN FIG. 9.
FIG. 11. DIAGRAM OF HORN GAP ARRESTER
FIG. 13. HORN GAP ARRESTER WITH RESISTANCE
FIG. 15. CONNECTIONS OF ARRESTER SHOWN IN FIG. 14

Lightning Arrester is a Safety Valve

A lightning arrester is a safety valve which is arranged to discharge dangerous electrical disturbances into the ground. A modification of an arrester is a so-called spark gap or bypass used in connection with some classes of apparatus to reduce the voltage in a coil by temporarily short-circuiting it.

The analogy between a lightning arrester and a safety valve is quite close. The requirements for an ideal protective device run closely parallel, and may be tabulated about as shown in the table, page 1055.

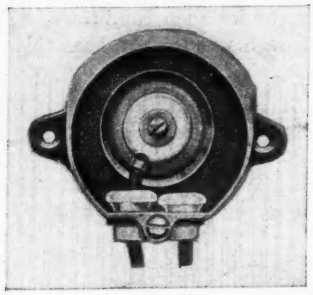


FIG. 5. COMMERCIAL FORM OF LIGHTNING ARRESTER

Unfortunately it has so far been impossible to combine in one arrester all of the foregoing qualifications. A device that combines to a satisfactory degree the first five is expensive and rather bulky. Of the cheaper arrester, one or more of the first five must be sacrificed.

Requirements of Lightning Arrester

Let us now analyze a little more closely the tabulated requirements; following the schedule, we come first to accuracy and sensitiveness. From the discussion of high frequency disturbances in the opening paragraphs of this article, it is apparent that damage may be done by any one or all of the following abnormal conditions:

1. Normal frequency at abnormal voltage.
2. Abnormal frequency at abnormal voltage.
3. Abnormal frequency at normal voltage or lower.

The voltage as considered above is, it must be remembered, not the "effective" or measured voltage, but the voltage at the peak of the wave. It could be possible so to distort a wave that it would become destructive—and still have its effective value normal and within safe limits.

It must also be borne in mind that the frequency can be zero; i.e., the current can be direct.

An ideal arrester from the standpoint of accuracy would then be one which would discharge under either abnormal voltage or abnormal frequency conditions.

It is obvious, too, from Fig. 1, that a number of crests or waves would have occurred in an almost inconceivably short length of time. An arrester, then, must respond quickly to abnormal conditions, and its "lag" should approach zero.

There should be no dead intervals in the operation of an arrester. For example, if the power current which would follow a discharge were interrupted by disconnecting the ground, and the method of doing this were slow, there would be a period of non-protection following each discharge. As an extreme case, take for example, the fused type (to be described later) in which the blowing of the fuse interrupts the power current. This design of apparatus would remain inoperative until the attendants replaced the fuse. Even a comparatively short period of disconnection might result in damage as disturbances often occur in rapid succession.

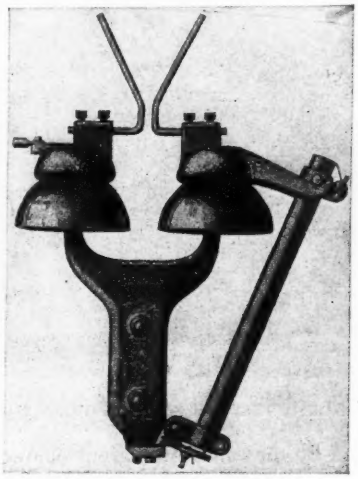


FIG. 12. COMMERCIAL FORM OF HORN GAP ARRESTER

The second qualification is that of "free discharge." This would, at first thought, seem to be merely a matter of making the ground connections large and of low resistance and reactance. If the problem were merely that of grounding the disturbance this would be sufficient, but it must be remembered that this "free discharge" must be accomplished without tripping the feeder circuit breakers; in other words, the rush of power current must be limited or cut off without interrupting the service. Furthermore it often happens that conditions arise in which the disturbance persists for a considerable length of time, and an ideal arrester must for that reason be able to discharge for quite a long time without damage to itself.

Next in order comes ability to interrupt the power current which invariably follows the arc set up by the abnormal conditions of voltage or frequency. This is a very important characteristic, and on it much money and inventive genius has been expended. To secure freedom of discharge—and at the same time have an arrester capable of rupturing a heavy current, has been the aim of a great variety of designs. The two qualifications require directly opposite characteristics in the apparatus; it is obvious that the rupturing strain is reduced by introducing a current limiting resistance, and that this same resistance also lowers the discharge capacity.

To permit free dissipation of the explosive violence of a discharge induced by a stroke near the arrester would require a ground path of practically zero resistance. If, in addition, this arrester were near the power house and, as often happens, two lines discharged at the same time, the result would virtually be a short on the system, and the rush of current would, until the automatic switches opened, be very great. To avoid interruption, the arrester should rupture the power arc before the breakers opened, and it can readily be seen that this would impose a severe burden on them.

We have already seen that switching can induce high frequency disturbances. This adds to the burden of the arrester, for it must "clear" the ground and interrupt a heavy flow of current and do it without setting up new disturbances. To make the matter still more difficult, large systems often get into a sort of unstable equilibrium in which a small disturbance produces disastrous consequences.

Aside from the technical consideration discussed above, there is too the more or less mechanical matter of accessibility. It must be possible to determine with a minimum of effort whether or not the arrester is in operative condition. Any design requiring complicated or laborious test methods, is undesirable.

TABLE SHOWING SIMILARITY IN REQUIREMENTS OF LIGHTNING ARRESTERS AND SAFETY VALVES

	Lightning Arrester	Safety Valve
First	Must be accurate and sensitive so as to open under certain predetermined conditions.	Must be designed to open at a certain predetermined pressure.
Second	Must have free discharge.	Must have sufficient area.
Third	Must be able to stop the discharge when normal conditions are restored.	Must close when pressure is reduced.
Fourth	Must by its operation not create fresh disturbances in the system.	Must discharge harmlessly.
Fifth	Condition of the apparatus must be easy to determine.	Condition must be readily determined.
Sixth	Must be economical.	Must be economical.

The commercial point of view must be considered very seriously. The expense of the arrester installation, interest, depreciation and maintenance must be kept to a point where the money involved is profitably invested. The "insurance premiums" paid for arresters must be proportioned to the value of the apparatus protected and to the importance of the installation. Engineers here often err by assuming that the protective investment should be governed by the apparatus investment alone. This is far from true, as the value of a transformer is often only a small part of the loss in a lightning burn-out. The value of the product produced by the power from that transformer may be such that a few hours shut-down means several times the value of the apparatus itself.

On the other hand, the destruction of a farm line transformer or one in residence section involves little loss beyond the cost of the apparatus and the labor expense.

It can thus be seen that the matter of arrester selection is not merely a matter of engineering—it becomes to a considerable degree a matter of business. Manufacturers recognize this, and have provided a very broad line of protective apparatus, varying widely for

a given voltage; such as, for example, 2300 v. from $5 to $500.

Forms of Arresters

The simplest form of lightning arrester would be a spark gap connected as shown in Fig. 2. It would be very cheap, but has the following defects: (a) It would not discharge high frequency voltages at the same potential as normal frequency voltage. This would mean, for example, that 13,000-v., 60-cycle voltage would discharge while 13,000-v., 500,000-cycle would not. This is expressed by saying that the gap has an "impulse ratio" of more than 1. Thus, if it took 26,000 v. of high frequency current to leap the gap, the "impulse ratio" would be 2. (b) It could not extinguish the power arc which would follow the lightning discharge unless the current involved were low, i.e., limited either by the generator capacity or by the line impedance.

Figure 3 shows two commercial forms of spark gap, consisting of two knurled cylinders separated by a non-adjustable air gap. It is used to relieve static stresses in the low voltage windings of high tension transformers. It is not intended for a lightning arrester in the ordinary sense of the word.

In Fig. 4 is shown a modified spark gap. The gap consists of two circular discs of metal separated by a non-adjustable airgap. This airgap is shunted by a high resistance. It is for use on a.c. voltages under 350 and may be used as a spark gap or as a lightning arrester. Light discharges pass through the high resistance (which is always in circuit) while heavier discharges jump between the discs. The mass of the discs is so great as to cool the arc and prevent its reforming after the power current has passed a zero point. Figure 5 shows a commercial form of this arrester in which the resistance takes the form of a high resistance block between the discs. It is made weatherproof by being enclosed in an iron box.

This arrester would perhaps not function satisfactorily on d.c. circuits, due to the fact that there would in that case be no zero point of current.

Figure 6 shows a third modification of a spark gap in which a number of parallel paths carry off the disturbance. The principle of this is that the power arc is finely divided and so is broken because each portion is too small to maintain itself. Figure 7 shows the external view and a diagrammatic view of a commercial form of this arrester. It is made with or without the spark gap and is suitable for voltages up to 750—direct or alternating. It consists merely of a block of carborundum fastened between terminal plates. When the voltage rises above normal the binding compound between the particles of carborundum breaks down and the abnormal voltage is discharged to ground. The power arc is divided up into many portions and goes out. It also has good discharge capacity, due to the large diameter of the carborundum disk.

Resistance Arrester

Comparable to the spark gap arrester in simplicity is the resistance arrester as shown in Fig. 8. It consists merely of a resistance constantly in circuit between the line and the ground. This is not used for alternating current but some traction power houses ground their trolley feeders through a water box resistance when a storm threatens. Considerable current is wasted, but a good degree of protection is obtained.

A commercial modification of the resistance arrester is used on direct current series street lighting systems and it consists of a block of lignumvitae having at its ends metal electrodes. These are connected to the line and to the ground respectively. Between the electrodes, in the surface of the wood, is burned a groove, thus furnishing a high resistance path from line to ground. Other grooves at right angles to this discharge path, form vents through which the gases formed by the arc are violently expelled. A second block, fastened on top of the one described, forms the cover.

An arrester of this type discharges in proportion to the violence of the disturbance. It furnishes a fairly free path to ground, and as the current following the arc is limited by the constant current characteristics of the circuit, it is readily interrupted by the action of the gases in the transverse grooves.

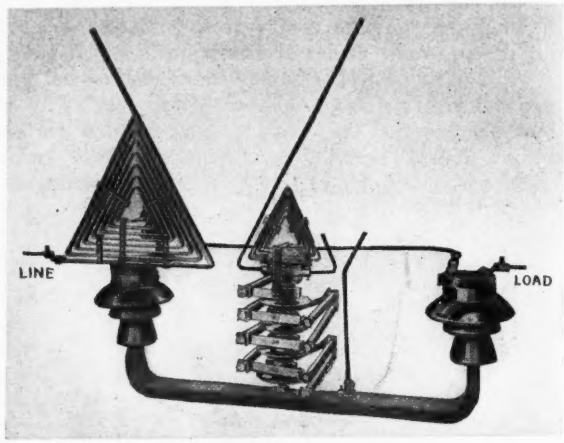


FIG. 14. HIGHLY DEVELOPED FORM OF HORN GAP ARRESTER

Condenser Arrester

The destructiveness of a disturbance varies with its frequency. A condenser between the line and ground, as shown in Fig. 9, should then, theoretically at least, form ideal protection against that part of the damage caused by the effect of the high frequency.

A commercial arrester operating on this principle is in use, but is not suitable for use on alternating current, as there would then be a constant loss through the plates. It is especially intended for street railway service. The manufacturers state that it has a capacity of 1 microfarad—"equivalent to the capacity of 100 mi. of average line." The outstanding features of an arrester of this type are that it discharges high frequency disturbances of low voltage, and that it permits no direct current to follow.

A modification of the condenser type is shown in Fig. 10. The advantage of this variation is that the condenser is disconnected from the line, and being short-circuited by the resistance, is always discharged. It therefore is able to handle effectively a slightly larger disturbance. In the commercial form, the spark gap is accessible through a small hole in the case, and if desirable can be used as a means of checking the action of the apparatus by inserting between the elec-

trodes a piece of paper. A discharge would be indicated by holes burned in the paper.

The Horn Gap

The action of an arc between horn gaps was early applied to lightning arresters. Figure 11 is a diagram of this, while Fig. 12 is a commercial form. The arc formed between the angles rises along the horns and is extinguished by the increase of arcing distance. A fuse as shown is sometimes inserted in circuit so that it blows in the event of a heavy rush of current which the horns can not rupture, and so avoids a shut-down.

An arrester of this type has the advantage that it is low priced, and a liberal number of them can be installed on a troublesome section of line. Its disadvantages are that it has a tendency to establish high frequency surges by the action of the arc, and that it may at any time become inoperative by the blowing of the fuse.

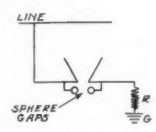


FIG. 16

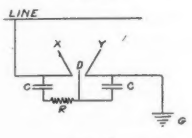


FIG. 17

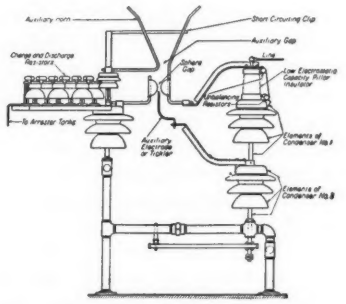


FIG. 18

FIG. 16. HORN GAP ARRESTER WITH AUXILIARY SPHERE GAPS
FIG. 17. MODIFICATION OF HORN GAP ARRESTER WITH IMPULSE RATIO OF LESS THAN UNITY
FIG. 18. COMMERCIAL FORM OF IMPULSE GAP

A variation of the horn gap is illustrated by Fig. 13, in which a resistance in the ground lead limits the power current to a value which can be handled by the horns. A well known commercial form of this type is designed for suspension from the line wire. This is an improvement over the fused arrester of Fig. 12 in that it can not be rendered inoperative so easily, and in that the viciousness of the arc across the horns is considerably reduced by the resistance.

It may be well to state at this point that the introduction of a resistance into the ground leg of an arrester, places it immediately in what is ordinarily known as the "unlimited application" class. In other words, the size of the generating equipment does not affect the application as the resistance limits the amount of ground current, regardless of the generating capacity, and makes its value depend on the maintained line voltage only. An arrester without ground resistance passes an amount of current inversely proportional to the total line and generator reactance—and must be designed accordingly. In other words, the application is limited by the size of the generating system.

Modifications of Horn Gap Arrester

Horn gap arresters are made in many forms and with many modifications. Figure 14 shows a highly developed form of horn gap with a number of features that add to its protective ability.

Figure 15 illustrates the scheme of connections of this arrester. It is essentially a combination choke coil and arrester. The ground leg has a choke coil and resistor in series, and these are in turn shunted by an auxiliary gap. Ordinary discharges will follow the choke coil and resistance to the ground, while a more severe stroke will jump the auxiliary gap. As soon as the initial surge is over, the auxiliary gap arc will die out (being shunted by the resistance and reactance); this will throw the ground impedance into circuit and lower the arc current to the point where the main horns can rupture it. The choke coil is so placed that it acts as a magnetic blowout coil and so further helps to rupture the power current.

Any horn gap arrester in which the gap is larger than the rods forming the horns has an "impulse value" of more than 1. The reason for this need not be discussed here, but the effect of this condition is as follows:

A horn gap set for, say, 20,000 v. (and intended to protect, say, a 13,200-v. line), will not discharge at high frequencies until a voltage far above 20,000 has been reached. In other words, in actual practice it becomes inoperative. If the gap is set to discharge at a safe margin at high frequency, it will be too close for normal frequency conditions, and may flash over on a slight rise of potential.

It has been found, however, that if the arcing points be spheres, the impulse ratio becomes unity and the arcing voltage is the same regardless of frequency. Sphere gaps are now standard on many lines of equipment and greatly improve the protective qualities. Figure 16 illustrates an arrester with auxiliary sphere gaps. The discharge takes place across the spheres first and rises to the horns, where it is ruptured. In commercial form, this type frequently has a choke coil mounted integral with it, and has a resistance in the ground leg as shown.

An arrester of this type meets most of the qualifications outlined at the beginning of the article. It has free discharge capacity up to the limits of the ground resistance, has unity impulse ratio, is low in first cost, and easy to inspect and maintain. It is extensively used in transmission line work.

An impulse ratio of unity is a vast improvement over one of higher value; it is equally true that an impulse ratio of less than unity would be still better. As has already been pointed out, a high frequency disturbance, even of a voltage lower than normal, can do considerable damage to inductive circuits, such as generator and transformer windings, and to safeguard against this a gap should have a selective action capable of discharging high frequencies at a potential lower than that of the normal frequency current.

Figure 17 illustrates a recent development in gaps which has this desirable feature. It has an impulse ratio varying from .3 under special conditions, to a commercial average value of .6 to .7. This means that a gap which would at 60 cycles flash over at 100,000 v., would at, say, 100,000 cycles flash over at 60,000 to 70,000 v.

At normal frequencies, the condensers cc pass very little current, but at high frequency the flow is sufficient to produce a drop in R. This makes the drop between

x and the tickler electrode d greater than between y and d—and the fractional gap xd breaks down. The remaining gap yd immediately follows. The effect is as if the gap xy were adjustable and automatically became smaller on high frequencies.

The commercial form of this device is known as an "impulse gap"—and is shown in Fig. 18.

It will be noted that the condensers are multipart insulators in which the cement forms the conducting plates.

This form of gap is not marketed for use as an arrester alone, but is designed for use with electrolytic arresters, hence the charge and discharge resistor on the ground side in the cut.

Power Factor in Polyphase Circuits

A Review of Proposed Definitions. By A. Nyman

THE TERM "power factor" as applied to single-phase circuits, owes its origin to an economic necessity. The capacity of the electric machinery and of the distribution network and the expense of supplying electric power are directly dependent on this factor. With the rise of polyphase systems, the same factor was applied to individual phases. As long as the loads were balanced, this factor was common to all phases and could be used to represent the load conditions accurately. As the number and magnitude of single-phase loads drawing power from polyphase circuit increased, it became more apparent that the old "power factor" was insufficient.

A number of possible definitions have been in use. As long as most single-phase loads are approximately balanced one against the other, there is little difference in results given by various definitions. Lately, however, large power loads with considerable unbalance have come into use and made it desirable to standardize on a definition which would be satisfactory from technical and

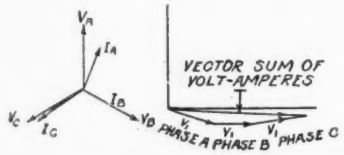


FIG. 1. DERIVATION OF POWER FACTOR FOR A PARTICULAR CASE OF UNBALANCED CURRENTS

commercial viewpoint. The A. I. E. E. and the N. E. L. A. have formed a joint committee to carry out this standardization. This committee has brought forward a wide discussion of this subject.

In general, three classes of people are interested in a suitable definition of "power factor":

The producer of electric energy.
The consumer of electric energy.
The manufacturer of electric machinery.

In considering the conditions affecting central station operation, the presence of unbalanced load has a direct result in the rising losses in the generating units and distributing network. Comparing unbalanced load with a balanced load of the same kilowatts, the power station must bear the cost of additional coal burned and the interest and depreciation on the additional plant capacity. This additional cost could form a basis for defining power factor. The disturbance of voltage, as created by unbalanced load, is a far more serious feature; its result is poor service from the station. The unbalance in voltage, if large, cannot be easily corrected. Synchronous motors or phase balancers can minimize this effect, but must be located close to the source of disturbance in order to be effective. Lagging current in the line has approximately the same effect on regulation as unbalance. It can be corrected by suitable appliances, but in order to be most effective, the latter must be located close to the source of lagging current. The two causes of poor regulation may be corrected by separate means. The cost of correction can be estimated separately.

The foregoing considerations suggest the use of two factors—(1) To represent phase lag in the system, assuming all the load balanced—(2) To represent unbalance. Such a method of measurement could have an exact scientific basis and could be made to represent each load condition accurately. Several practical objections are raised against this method. The use of an additional term like "unbalance factor" would involve a further complication in determining the rate to be paid. Producers and consumers must all be conversant with the technical meaning of this new term in order to appreciate its importance and avoid disputes.

From the customer's standpoint, both the quality of the service and the fairness and simplicity of the rates are factors of importance. The users of large single-phase loads must be assured that whatever penalty is placed on their type of load is commensurate with the actual cost of supplying this load and of maintenance of service to other customers. Certain consumers, such as large electric furnaces or single-phase railways could be induced to install phase balancers. This would protect the rest of the system and bring the burden of unbalanced load directly to the customer.

Polyphase machinery on circuits with unbalanced voltages draws unbalanced currents. These currents while beneficial to the rest of the system, are a source of losses and reduction of capacity to the machinery through which they flow. Any scheme that would apply a single factor for both phase lag and unbalance would treat such load unfairly. With two separate factors, the unbalance existing in the polyphase machinery will not necessarily affect the charge. The unbalance factor can be simply overlooked. On the whole, a scheme for measuring phase lag and unbalance separately would be desirable, provided the calculations of rates were simple.

From the manufacturer's point of view, the discussions of unbalance factor brings up a number of points concerning the protection of polyphase machinery on unbalanced voltage systems. All such machinery is subject to additional losses when such voltage exists. These losses are partly distributed throughout the machine and partly concentrated in certain portions of the machines. Consider the case of an induction motor with the voltage in one phase higher than the others. This phase will

draw a comparatively high current and the winding of this phase will be overheated. At the same time, an induced voltage is added to the rotor, which creates further losses distributed throughout the rotor.

For close technical analysis of working conditions, separate measurements of power factor and unbalance appear desirable. In this way the capacity of the machinery can be determined with due regard given to working conditions of phase shift and unbalance. Both factors must be also included in wording the contracts for machinery. This will, unfortunately, introduce some new clauses in an already highly technical legal document.

As far as metering is concerned, it is possible to design meters to measure a power factor of almost any kind of definition; however, separating the measurement of power factor and unbalance permits the use of very simple schemes for measuring both. Meters of standard types of construction could be used.

Possible Definitions

Single factors—Several definitions have been suggested to represent the power factor in a polyphase system and take account of unbalance. A single factor is then used for complete determination of the load conditions, as opposed to a double factor, one for measuring phase shift and the other for measuring unbalance. The following single factors may be mentioned.

$$\text{Power factor} = \frac{\text{total watts}}{\text{arithmetic sum of volt amperes}} \quad \ldots\ldots (1)$$

where volt amperes are determined by measuring the current in each phase and the voltage from each phase to an artificial neutral formed by three equal impedances. This definition has been tentatively suggested by the Joint Committee of the A. I. E. E. and N. E. L. A. as one of two alternative definitions. It takes account of unbalance, though not on any scientific basis. Its main advantage is simplicity and ease of derivation.

$$\text{Power factor} = \frac{\text{total watts}}{3 \times \text{r.m.s. current} \times \text{r.m.s. volts}} \quad \ldots\ldots (2)$$

where r.m.s. current is derived from the three measured values of current by taking the root mean square of the three values. R.m.s. volts are derived in the same way from the voltages, measured as in definition 1.

This definition gives a value of power factor which bears a definite relation to the losses in polyphase supply circuit; namely, the losses are the same as would exist

$$\text{with a balanced, in-phase load} = \frac{\text{measured watts}}{\text{power factor}}$$

This is the same relation as exists for a single phase power factor.

The chief disadvantage of this factor is its complicated derivation. Direct measurement of this power factor would be difficult, if not impossible; however, meters to measure r.m.s. of three currents or r.m.s. of three voltages could be constructed.

Double Factors—The power factor for this method of considering the problem disregards the effect of unbalance. A separate unbalance factor is advocated to measure the latter. Different ways of defining "power factor" on this basis have been suggested. The results given are, however, nearly identical.

$$\text{Power factor} = \frac{\text{total watts}}{\text{vector sum of volt-amperes}} \quad \ldots\ldots (3)$$

This definition is variously referred to as vector power or Italian power factor. It is the second alternative definition suggested by the joint committees. The vector sum of volt-amperes can be obtained by geometric construction, using volt amperes as vectors with the respective corresponding angles of lead or lag in each individual phase. Figure 1 shows the derivation of this power factor for a particular case of unbalanced currents. It will be noticed that for a balanced voltage condition the current unbalance is completely disregarded. If, however, a voltage unbalance exists, the power factor measurement is affected.

In order to understand the difference between this definition and the following a brief outline of C. L. Fortescue's method of analysis will be given.

It can be shown that any three-phase system with neutral open circuited can be decomposed vectorially into two balanced three-phase systems, Fig. 2,—the one with the sequence of phases in one direction, the other with the sequence in the opposite direction. Thus the

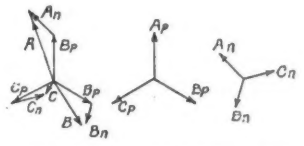


FIG. 2. THREE-PHASE SYSTEM WITH NEUTRAL OPEN CIRCUIT RESOLVED VECTORIALLY INTO TWO BALANCED THREE-PHASE SYSTEMS

system A, B. C. is decomposed into the system $A_pB_pC_p$, which may be called positive sequence, and $A_nB_nC_n$ which may be called the negative sequence. It can also be shown that this decomposition is perfectly definite for each particular case,—that is, only one combination of magnitudes and phases of this nature can satisfy each condition. It can be shown furthermore that the positive sequence is the only useful part in polyphase machinery. In fact, the negative sequence of currents is equivalent to a current flowing in a direction opposite to that of synchronous rotation of the machine. The result is a reduction in working torque of motors and additional losses in all polyphase machinery. In every circuit carrying currents of positive and negative sequence, the total losses equal the sum of losses due to the positive and the negative sequences. The total power and total reactive power are similarly equal to the algebraic sum of the respective values in the positive and in the negative sequences. In a balanced system, it will be found that the negative sequence disappears.

The above analysis of a three-phase system into a positive and a negative sequence resembles in many features the analysis of a single phase condition into in-phase and out-of-phase components, or into real and reactive powers. It is evident that the negative sequence could be considered as the most correct and definite measurement of unbalance, which can be treated as independent of the balanced or positive sequence, but obeying the same laws. The total resulting condition is then the sum of the effect of positive and negative sequence.

$$\text{Power factor} = \frac{\text{watts positive sequence}}{\text{volt amperes positive sequence}} \quad \ldots\ldots (4)$$

$$\text{Unbalance factor} = \frac{\text{current negative sequence}}{\text{current positive sequence}}$$

This definition of power factor is different from definition 3 only in case of voltage unbalance. This is apparent by considering the volt amperes due to the negative sequence current and positive sequence voltage: the vectoral sum of these volt amperes is equal to zero. Hence only the vector sum of volt amperes of positive sequence current and positive sequence voltage determine the power factor (3) and give a value equal to that of definition (4); however, if a negative sequence voltage is present, the negative sequence voltage and the negative sequence current give a value of volt amperes which add vectorially to the volt-amperes of positive sequence. Thus the value of power factor by definition (3) will differ from that by definition (4). The latter definition disregards completely the effect of unbalanced voltage.

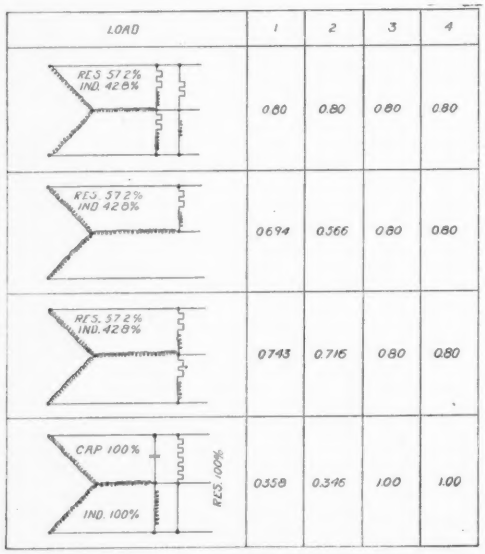


FIG. 3. POWER FACTOR OBTAINED BY DEFINITION (1), (2), (3) AND (4) UNDER CERTAIN LOAD CONDITIONS

The unbalance factor gives a direct measure of unbalanced current. This definition is preferred to any other which would include the voltage unbalance to define the unbalance factor. In practice the voltage unbalance is small and it is really the current unbalance that is the origin of harmful effects.

As mentioned above, a distinction must be made between the unbalance created by a single phase load, and that drawn from a polyphase machine by virtue of unbalanced voltage. Such discrimination could be achieved automatically by measuring the phase of negative sequence current with relation to negative sequence voltage.

$$\text{Power factor} = \frac{\text{real power positive sequence}}{\text{real power pos. seq.} + \text{reactive power pos. seq.}} \quad \ldots\ldots (5)$$

This definition is equivalent to definition (4) except stated in a different way. Definition (3) differs from it by the fact that it takes into account the real power of negative sequence and reactive power of negative sequence. The advantage of definition (4) or (5) over definition (3) is in the fact that it disregards the voltage unbalance completely. The unbalance condition can then be measured independently by unbalance factor.

It is possible to construct circuits which will measure power factor and unbalance factor accurately according to definition (4) and use meters of almost standard construction. This would be, of course, of immense advantage on existing power networks, and with the manufacturers of measuring instruments. Easy conversion to meters suitable to this new definition is made possible. The practical difficulty in accepting this definition is that a new method of analysis of circuits must be introduced and accepted by a majority of interested parties.

In the matter of rate making, the following procedure has been suggested. The present method of charging for low power factor should be complemented by introducing a similar charge for unbalance factor. It will be, of course, necessary to get the approval of technical authorities of government institutions before any such method could be universally accepted.

Figure 3 illustrates by concrete examples the results given by various definitions under certain load conditions.—The Electric Journal.

Useful Transformer Connections

By G. Harvey

THE OPEN delta connection of transformers for the three-phase circuit has the advantage that two instead of three transformers suffice for applying three-phase power. The great advantage in many classes of service, is, however, that if one transformer in a three-phase bank connected in delta breaks down, the other two transformers remaining in service are able to continue to carry the load as soon as the defective unit has been cut out of service. These two transformers are connected in open delta.

As ordinarily connected, however, the three transformers are tied in solid together, so that if one fails its leads must be disconnected from the other two before they are able to be placed back in service. This means protracted delay which may be exceedingly serious where electrically driven turbine auxiliaries, pumps and similar apparatus is being supplied with power. Moreover, the fact that a change of connections must be made tends to counteract the advantage of the open delta connection.

By connecting delta-connected transformers as shown in the accompanying sketch (Fig. 1), any one may be taken out of circuit without interfering with the operation of the other two. Motor-driven apparatus will continue to function as if the third transformer were still in circuit. This means that if one transformer fails it will clear itself by blowing its fuses (or it may be cleared by opening the switches if disconnect switches are used instead of fuses), with virtually no interruption, only the minimum, to service. It will be noticed

that the fuses or disconnects are located "inside" the delta. If fuses are used, they should be of such size that they will operate only under the most extreme short circuit such as a transformer break down.

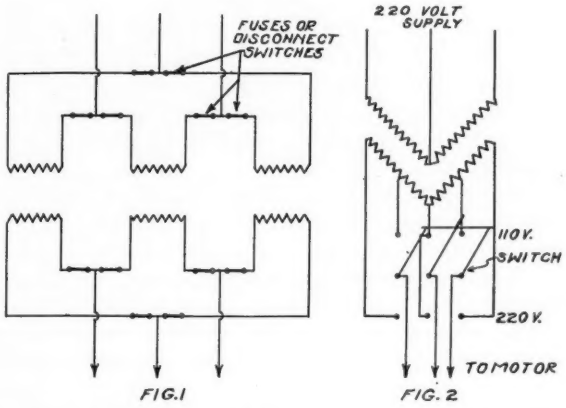


FIG. 1. THREE-PHASE DELTA CONNECTION READILY CONVERTIBLE INTO OPEN DELTA

FIG. 2. OPEN DELTA CONNECTION APPLICABLE FOR STARTING MOTOR

In using two instead of three transformers, it should be borne in mind that the three-phase of the two transformers is only 58 per cent of the capacity of three transformers; that the combined capacity is but 86.6 per cent of the single-phase capacity of the two transformers.

Another connection of transformers in open delta that is rather interesting is that shown in Fig. 2. Here two transformers supply a pump motor instead of three transformers in delta. An auto-starter was not available for providing a lower voltage for starting so that it was decided to use the middle point of the secondary winding of the transformers, which were wound for 2200 to 110 and 220 v.

To start the motor the switch is thrown into the upper position and then as the motor comes up to speed is thrown to the lower position which gives full line voltage to the motor. This connection is quite satisfactory where half line pressure is sufficient for starting. In doing the wiring it is important that the half and full voltage wires in the same phase are connected to the proper switch terminals, otherwise when throwing the switch from the top to the bottom will reverse the current and so subject the motor to excessive shock. For motors up to 25 hp. where voltage fluctuations are not serious, this connection dispenses with one transformer and an autostarter. As there is a loss of 13.3 per cent in transformer capacity due to phase displacement because two transformers take the place of three, the open delta connection requires correspondingly larger capacity transformers. These connections are particularly useful for temporary and emergency work.

Gas and Oil Engine Accidents

A Discussion of the Causes of Gas and Oil Engine Accidents and Precautions to Be Taken. By C. A. Joerger

GAS AND OIL engines, like all other types of engines are subject to accidents. While in many cases such accidents differ in no way from those common to steam engines, there are nevertheless some which are peculiar to this particular type of engine and call for special treatment. In this article, the direct causes of the more common gas and oil engine accidents will be discussed, what the failures are due to and what precautions are necessary to take to prevent them.

Broken Crankshafts

Crankshafts are almost invariably made of ingot steel, and when they break it is generally found that the fracture is not of recent origin, but has been gradually developing. Such fractures frequently occur at the junction of the crankpin with the crank web as indicated in Fig. 1. Apparently a surface crack is set up in the first instance, and this gradually develops until the sound metal remaining is insufficient to carry the load, at which point final fracture takes place. On the examination of the fractured surfaces, it is then seen that a considerable area is black and oily, and is worn smooth by slight movement between the surfaces, while the part that finally gave way is the only portion showing a bright metallic fracture. This appearance of the fracture sometimes leads to the conclusion that failure is due to an old defect or flaw in the metal, but generally failure in this way is the result of over-stress from some cause or another, and the material of the shaft, if tested, would probably be found to be of good quality.

Figure 2 shows in what parts of the shafts fractures are most likely to occur, and these parts should be carefully examined every time the crankpin or journals are bared. It will be noted that the cracks seldom run lengthwise in a shaft, although a crack through one of the journals often runs in a diagonal direction. As is to be expected, that part of the shaft most likely to fail is the part which is most highly stressed, viz.: the portion between the crank and the flywheel.

In the earliest stage, such cracks are difficult to see, and a slight surface mark is not readily distinguished from a crack.

If a crack is suspected, a spring test may be made as follows:

Place a chock of wood or a plank under the crank web, and then exert a pull on the flywheel rim so as to put the portion of the shaft which contains the suspected crack in torsion. The surface should be rubbed quite clean with a piece of waste to commence with, and if there is actually a crack it will show up after sharply pulling the flywheel a few times, as oil will commence to exude from between the fractured surfaces.

Anything which causes a shock at moment of explosion is likely to over-stress the shaft, and an engine which has been subject to pre-ignition, or has been worked with a slack flywheel key, is likely to break down sooner or later with a fractured crankshaft. Another cause of over-stress in the shaft is sticking or seizing of the piston. Gas engines are fitted with heavy flywheels in order to maintain a regular speed, and if a sudden

resistance be introduced the stored energy contained in this heavy flywheel revolving at a speed of 180 to 200 r.p.m. is capable of producing a very high stress in the shaft.

If all the bearings are in line and the shaft correctly bedded, there should be no bending moment on the crankshaft, the stress being torsional. When, however, fractures occur across the webs, such as are shown at B and C in Fig. 2 it may be taken that the shaft is subject to bending due to the bearings being out of line, and in all probability the outer bearing is no longer in correct alinement, with the engine frame. By very carefully gaging the distance between the webs with a

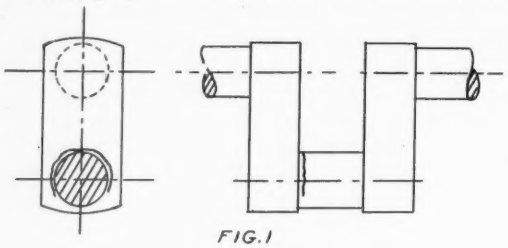


FIG. 1

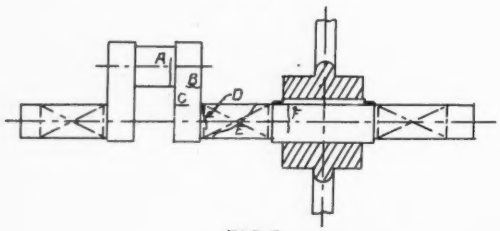


FIG. 2

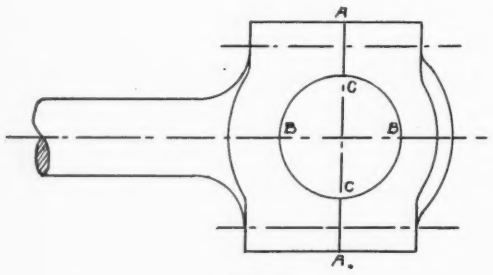


FIG. 3

FIG. 1. SHOWING CRACK AT THE JUNCTION OF THE CRANKPIN WITH WEB

FIG. 2. SKETCH SHOWING WHERE SHAFT FRACTURES ARE LIKELY TO OCCUR

FIG. 3. ILLUSTRATING PROPER POSITION OF THE TWO HALVES OF BEARING

micrometer gage, both when the crank is at the top and when the crank is at the bottom, the amount by which the webs are sprung out of their true parallel form can be measured and the height of the outer bearing adjusted until this springing is eliminated.

Persistent heating of the center bearing, excessive endwise movement at the ends of the crankshaft, or a slight "wobble" at the rim of the flywheel, may result from such bending.

In another way also, hot bearings influence the life of a crankshaft, as if it be overheated the journal may develop surface cracks, and if the shaft is fairly highly stressed one of these otherwise harmless cracks may form a starting point from which a serious crack will develop.

Precaution should be taken against over-stress in the shaft from any of the various causes mentioned above, and in particular it should be seen that attention is paid to the following matters:

1—See that the piston and combustion chamber surfaces are clean and free from carbon deposit as that is liable to become incandescent and to cause pre-ignition.

2—Make sure the flywheel is keyed tight and that no movement, however slight, can take place between the flywheel boss and the shaft.

3—Keep the surfaces of the piston and liner clean and the cylinder lubricator in order; use a good gas engine cylinder oil.

4—Attend regularly to the main bearing lubricators. These bearings are usually of the ring-oil pattern, and the oil wells require occasional cleaning out and filling with fresh oil, otherwise the oil may become too thick and the rings cease to revolve.

5—Have the alinement of the shaft bearings checked from time to time, either by an engineer of the plant or by one of the engine-maker's erectors.

Connecting Rod Bolt Failure

This is one of the most frequent recurring accidents, and owing to the extensive damage which often results from such failure, repairs are a costly matter, and the engine is liable to be out of commission for a considerable time.

A broken piston and liner and bent connecting rod is the least amount of damage which may be expected, and in some cases the engine has been completely wrecked through failure of one of the connecting rod bolts. As the piston is not infrequently shot out of the cylinder, there is also considerable risk of injury to any person in the engine room.

Bolts break through over-stress, and in the most cases over-stress is caused by faulty adjustment of the brasses, resulting in knocking. Other causes of over-stress in the connecting rod bolts are pre-ignition, seizing or sticking of the piston, and in cases of small engines, using excessive force when tightening up.

In a correctly adjusted bearing the two halves of the brass are quite hard up together at the point AA (Fig. 3), while there is just sufficient clearance between the pin and the brass at BB to allow of a film of oil. Under no condition must a bearing be run with the joint AA slightly open and the bolts slack; if necessary, a thin liner may be inserted at the joint, but the bolts must be quite tight and the braces bolted together solid.

If the brasses are too slack on the pin through wear and there are no liners at AA which can be removed to let them together, they require "stripping"—that is—taking off, carefully filing across the joint and bedding. After adjustment to give the proper working clearance on the crown of the brasses, further clearance must be given at the sides CC for a distance of 1 in. to 2 in. on each side of the joint, so as to allow free flow of oil. Crankpin bolts are commonly fitted with double nuts, so that when adjusted and tightened up the nuts may be locked together; they are further fitted with a split pin for security. When first sent out from the shop this split pin is hard up against the outer nut, but after the brasses have been adjusted once or twice there will be a clearance between the split pin and the nut. This

clearance should be filled up with a washer or washers so as to prevent the nuts from slacking back.

Gas and oil engine users are advised to renew the connecting rod bolts every three years if an engine has been in regular work for ordinary factory hours. A new set of bolts should be obtained from the engine-maker but if, for any reason it is necessary to have bolts made elsewhere the greatest care must be taken to ensure that the material and design are suitable. Referring to Fig. 4, sketch A shows the design of bolt used by leading gas and oil engine-makers, and this is the design which should be followed. The shank of the bolt is turned down to a diameter equal to the diameter at the bottom of the thread, and the change from one size to another is not effected suddenly, so as to have a square shoulder, but gradually. This is important, as a bolt subjected to repeated stress will fail much sooner at a sudden change of section than at any other point. The finish of the thread is another important detail as any ordinary bolt, such as is shown at C, is weak at the point where the thread finishes; the thread should run out on the reduced shank and not be cut into the full diameter. A feather is necessary under the head to keep the bolt from turning, and this feather should be drilled into the head as in sketch A, not in the shank as in B.

If the bolts are worked with the nuts slack they will be severely stressed and they will stretch and become deformed and eventually fail.

Cracked Cylinder Jacket

Overheating, due to defective water circulation, is the most common reason for cylinder castings cracking. In most gas engines circulation through the jacket is on the "thermo-syphon" system, where the jacket and the tank or tanks are connected, as shown in Fig. 5. With this arrangement circulation is set up and maintained by the hot water in the return pipe rising, and as the force producing circulation is only very slight the pipes and water spaces require to be kept clear and free from obstruction if it is to be effective.

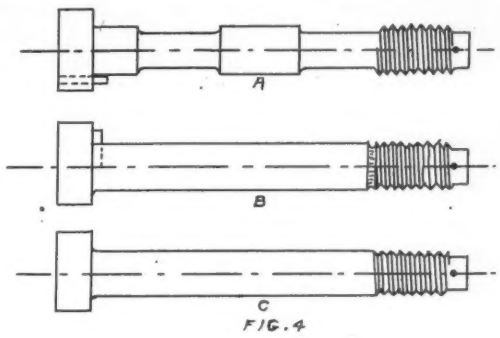
In the "thermo-syphon" system the force which causes circulation is the difference in weight between the column of hot water and the column of comparatively cold water in the pipes, and in order to obtain a sufficient force and insure a fairly brisk circulation the tanks must be placed at a high level relative to the engine. The bottom of the tanks should not be lower than the center line of the engine and wherever practicable should be a foot or two above it. The return pipe from the engine to the tank should rise gradually throughout its length and should have no dips where air could be trapped nor any sharp bends.

When two or more tanks are fitted in series it is necessary to ensure that the water flows successively through each tank from the bottom to the top, and for this purpose the tanks are usually provided with an internal pocket. These pockets or baffles are apt to corrode about the water level and require repairing as, unless they are effective, the water will flow across the top of the tanks only instead of following the required course, and in consequence will not be properly cooled.

Scale in the pipes or jacket is probably the commonest trouble of all as most water puts down more or less deposit when heated. If the city water is known to be hard, it is advisable to avoid its use as far as possible by collecting rain water from roofs, etc. Whenever the jacket water spaces are washed out and scale removed the joint of the return water pipe on the top of the jacket should be broken and the pipe itself cleared, as that is a point where deposit is likely to occur.

Overheating is not the only danger, as jackets have been cracked through using very cold water; in some cases ice water from the refrigerator plant was passed through the engine, plainly a bad plan.

Whenever cold water from the city mains is used, it is necessary carefully to regulate the quantity, so as to give an outlet temperature of 120 deg. to 150 deg. F., and it is also important to fit a funnel on the outlet so that should the supply be cut off at any time, the fact



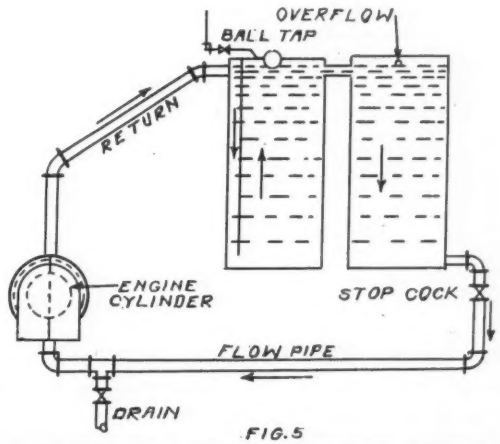


FIG. 4. PROPER AND IMPROPERLY DESIGNED CONNECTING ROD BOLTS

FIG. 5. THERMO-SYPHON CIRCULATING SYSTEM

would at once be noticed and the temperature could be checked from time to time.

In order that the engine jacket may be readily drained a stop cock is required on the flow pipe, as shown in Fig. 5. If this stop cock be shut and the ball tap tied up, the jacket can be drained by means of the drain tap without emptying the tanks. Occasionally a stop cock is also fitted in the return pipe, but this is objectionable as it carries with it a danger of bursting the jacket through expansion should both stop cocks be closed when the engine is started up.

Frost Accidents

Many gas engines are in use only at irregular intervals, and with such engines it is necessary to guard

against the risk of a cracked jacket owing to the water freezing.

Some users leave a gas jet burning near the engine or if the ignition is by hot tube they keep the Bunsen burner alight; this, however, is not sufficient if there is a hard frost, and a gas jet, to be effective, requires to be placed immediately below the jacket, not several feet away. A safer plan is to drain the jacket, but when that is done it is necessary to make sure the stop cock is tight. In a number of instances jackets have been frozen up when the stop cock was shut owing to its being leaky. The drain tap is usually of small size and if it is dripping an icicle is soon formed, which seals the tap, with the result that the jacket fills up and, if the frost holds, a burst jacket is the result.

Bursting of the stop tap through frost occurs frequently, and although renewal is not an expensive matter much inconvenience is caused through the engine being out of use till a new one can be obtained. These stop taps are usually made with a hollow plug and when closed the plug remains full of water, which may freeze up and burst the tap.

An accident of this kind may be guarded against by drilling a drain hole in the plug in such a position that when the tap is shut the hollow plug will drain itself.

Piston Cracked When Overhauling

It is not an uncommon thing to see a piece broken out from the front edge of the piston. This may have occurred through the connecting rod bolts breaking but in many cases it has been caused when overhauling, by allowing the connecting rod to fall against the piston when withdrawing the piston and rod.

Before uncoupling the connecting rod at the crankpin a piece of timber should be laid in the engine bed onto which the rod can be lowered, and after the piston and rod have been withdrawn care is required to avoid letting the rod fall sharply against the piston mouth when placing them on the floor.

Sideshaft Seizing

Stripping of the scroll wheel teeth, through which the sideshaft and the governor are driven, occurs with considerable frequency. In a few instances stripping is caused by the teeth being worn or being too deep in gear, but in the greater number it is due to the sideshaft or the governor spindle seizing. The more modern engines are fitted with ring-oiled bearings for the sideshaft, but in older patterns lubrication of this part is by hand and seizing is directly due to neglect of lubrication.

Ring-oiled bearings are automatic in action as long as the oil well is supplied with clean oil and the rings are revolving freely. In course of time, however, oil becomes gummy, and unless the well is cleaned out and refilled the rings will commence to stick and the journals will go dry and seize.

Valves Sticking

Fracture of the valve levers occurs more often when the engine is being pulled round by hand then when it is at work, and is caused by the valves sticking on their seats owing to the tarry or gummy deposits.

Before pulling the engine round, the valves should be lifted by depressing the levers to see that all is free. Failure of the valves sometimes takes place as the result of sticky valve spindles, the valves failing to close until explosion occurs, when they are banged onto the seats with excessive force.—Oil Field Engineering.

Trouble Hunting---VI

In Which I Obtain a Higher Vacuum and Increase the Evaporation. By John Pierce

IT IS strange that we can always see, after we have gone to many hundreds, and oftentimes thousands, of dollars' worth of expense, how we can improve things that we were thoroughly convinced previously were perfect. This is what happened to my friend, the old master. He had, many years ago, built a cooling pond, which, when first conceived in his mind, left nothing to be desired. Hardly had it been built, however, until it appeared that by adding a little, and shaping the new addition a certain way, a decided improvement could be made.

Accordingly the change was made, and then another chance for improvement could be seen, until finally it was decided that a complete new pond should be built embodying the last grand idea, and that the old one should be used in connection with it. The new one was very good, though small, and the old one looked like what I imagine that sunny city of Italy, Venice, I believe, would look like were it stripped of all its houses and just the canals left. I don't know much about Venice, but anyway she didn't have anything on the old number 1 pond. The loss of water from the overflow at the jackets on the furnaces and from evaporation was so great that it required a 3-in. stream of water at 40 lb. pressure to keep up the water level in the ponds. The water returning from the jackets entered number one pond in one corner and circulating through the little "Italian city" (we give it that name), flowed over a diving wall and board and went back to the intake of the pumps. The fresh water was shot into the pond at the point of entry of the returning hot water, the idea being that in plowing around through the various channels and over the diving wall it would so mix with the hot water that there would not be any hot water left at the intake, but that it would all be nearly as cold as the fresh water.

Now, this same intake served to feed the motor-driven centrifugal that furnished water to the jet condenser, and it was essential that we get as cool a water for our condenser as was possible. This water at the intake varied from 70 to 85 deg. at its coldest, and from 90 to 125 on an ordinary summer day. I was a little bit afraid of myself in this case and had to be very foxy. I took note of the reports for many months and found the vacuum stood at 18 to 19 continuously. I rather felt that this could be improved somewhat, though I was not sure. I ascertained that we were at something like 6000 ft. above sea level, and I was not going to take any chances and let anyone have the laugh on old Uncle John. So I looked up my "tables" and found it was

possible to do a little better than the best, which was, as I have said, 19 in. But in order to make sure of myself, and to know that to my intended change belonged the credit, in case any credit was due, I went over all the flanges, couplings, fittings, valve stems, etc., in the exhaust lines leading to the condenser from the various engines. Also the hot air pump and all its fittings.

I found everything in fine shape and no leaks. Then I watched my chance and hooked a fire hose onto the 3-in. pipe and ran the water directly into the mouth of the intake and made a run for the gages. At first I was too impatient and made up my mind that I was not going to accomplish anything, but I filled up my old pipe and waited. I had not said a word to anyone regarding my object, and nobody knew I was experimenting except my peons who were minding the hose. Finally, however, the needle on the gage began to go up a little and little by little it kept climbing until it had reached 20½. This was exactly at noon and during the very hottest part of the day. I sent a boy running and had the hose taken off. In less time than it had taken to climb up, the needle climbed back down. After returning from my dinner, I tried it again and had the same results. I then left it off and apparently forgot it.

After we had made our rounds together at nine that night, the old chief and I went home—he to go to bed, I to return and throw in a 3-in. pipe line to the intake, in place of using the hose. I put a pair of gate valves at the end of the old pipe so that with a "tee" I could close the new line, and spill the water at the old point in case anyone was doubtful as to the real cause of our gain in vacuum. Turning the water through the new pipe, I went home and to bed.

In the morning after I had made my first rounds and issued my requisitions for lubricants, I was passing my office on my way to make my round of tracks when I heard the old chief cussing like a river pilot. I rather guessed what was exciting him, but I did my best to hide the grin and look serious, and went in. When he saw me, he let out a roar and told me to send for the men who were just going off duty in the plant and find out "what the hell's busted loose; that they can't even read a gage any more—why, just look at this, from midnight till morning the vacuum has stood at 21 and I'll be damned if I don't fire that whole bunch of greasers if they can't stay awake long enough to make correct reports."

I sent for the men and they came, and all declared that their readings were proper, and that the gage still stood near the 21-in. mark. The old chief said it could not be, for it never had been and that the gage must be wrong. Then he told me to have a new gage put on and calibrate the old one. The new one showed the same results and then I told the old fellow. I thought he'd get mad, but he didn't. He was much pleased over it, and took me out and we had a drink from his private bottle. I would like to say, here, that some may get the idea that I was trying to get the old chief's job, but you will remember that I said, previously in these articles, that I came as the assistant and soon to be full master mechanic, the old chief having resigned and only staying with me until the 90 days' notice given was up before leaving. So those who may think I was after his job are wrong, for he had already given it to me. In Mexico a good man don't get up and leave on 10 or 20 days' notice, but gives his company plenty of notice, remaining in charge until his date set has come to hand. And this old chief was an extremely good man, and taught me many things for which I am indeed grateful. He frankly told me that he was an old man, had been a fairly old man when the company sent him to this plant from one of their plants in the northwestern part of the United States, and that there were so many duties given him and among them many things he'd never done before, that he simply had not had the time to plan new things. Therefore it is no discredit to him that there were some things which he had left undone, for he certainly had done many things without these few which he had omitted.

From the increase of vacuum I found, naturally, that we handled one load a little better and used a trifle less fuel and water. I next began to study the boiler problem, thinking to increase their steaming powers, and to increase our evaporation per pound of fuel.

I HEARD THE OLD CHIEF "CUSSING" LIKE A RIVER PILOT

In this country we have a very peculiar fuel oil that goes by the name of "chapapote." Whenever you hear the word "chapapote" you realize that you've got up against something. It tests from 9 to 11 deg. Baume and she sure is a vile thing. In fact, she is so cussed that whenever anyone wants to say the nastiest thing he can say, and say it in the nastiest way, he expresses everything and then some by simply saying "chapapote." When you want to tell a man that he is a low down yellow dog, lower than a snake, with less brains than the ordinary worm, you simply call him "chapapote"—but there it is time to look out, for if you have in the least misjudged him and he has the spunk of a water bug he's coming at you, and coming strong. If you want to know what chapapote is, just go and get a barrel of elastic roof paint, and add a few smells to it and you have it. I've paid, over in the States, fancy prices many times for roof paint for my roof, or stack paint for my stack and then discovered, after coming to Mexico that I'd simply been buying barreled chapapote and paying 10 prices for it. Even at that I've no cause for complaint other than having been stung on the price,

for as a roof paint it has no equal, and for stacks it can't be beat. Once it touches anything, it sticks. Water won't move it, and it laughs at soaps. After it has dried, it simply has to wear off and will hardly burn. I have a dandy pair of soldier pants which I was very proud of. They still look well when viewed from the front. From the rear you'd think I had a blackboard fastened to me. They won't bend, and can't break. I am thinking of getting and carrying a piece of chalk so my boys can chalk up any little notes or memorandums, and all because I sat down in some "chapapote."

Now, in burning this stuff under boilers one has to heat it very hot; I had done quite some experimenting with it from various degrees ranging from zero to 250. I found 150 deg. was the best heat to put on it, for under 150 it did not vaporize as it should, and over 150 it would begin to gas. At 250 it was almost impossible to burn it, because of the flarebacks it caused. Finally I settled down at 150 and arranged my furnaces. When I took over the works the grates were arranged according to the burner maker's blueprints, and in fact the furnaces had been arranged by a man from the factory.

At this point I'd like to point out the sometimes inefficiency of theories. Every engineer under the sun knows that theory cannot always be put into practice, and they also know that there are some men who simply can't do anything without "blueprints" and think that because the blueprint is "thus" or "so" it simply must be and would not for anything change the design the least bit.

This man who arranged the furnaces was one of those "blueprint" men, and nobody about the place could "show me." Well, it was a new thing, and nobody was in a position to tell him any different. Therefore the furnaces were installed exactly according to "prints" and the oil turned on.

They did fine—that is they did at first, but on easy firing and before the furnace was thoroughly hot, the burners would waste a little oil, which, dropping down on the exposed parts of the grate bars soon had them filled up, and no air could come through. Naturally the boilers steamed very poorly and smoked badly. After I discovered the trouble, each boiler was cut out at the end of four days and three peons were kept busy cleaning and changing grate bars. My first move with the furnace was to remove the entire set of grate bars, build a new wall 32 in. from the dead plate, build a floor from the point of the new wall sloping to the rear, reaching the bottom of the combustion chamber at the point where it joined the rear wall. I then raised the burners about 10 in. and pointed them parallel with the floor, and left the space between the dead plate and the new wall entirely bare. On firing up, I found a slight saving made in oil, a chance for a hotter fire, and no necessity at all for the three men who cleaned grate bars. I felt much gratified with the results, for while the saving in fuel did not amount to a great deal, the pay of the men was a little item in our favor; besides giving me a chance to force the boilers at any time without first having to clean and change the grates.

I found one serious drawback to this, and cast about for means to remedy it. These boilers were fed by a feed line running into the end of the boiler about 6 in. from the bottom. The blowoff was a separate pipe, and one thing a Mexican simply won't do is to blow down his boilers. That, by the way, is why the Mexican locomotive will not stay in service more than a month without going to the boiler shops to be patched. The water carried considerable lime and alkali and therefore should have been blown down frequently. As this was not done, the matter filled them up and hardened and the next thing I would find my "blowoffs" burned and bursting. I therefore cut off the feed lines, plugged the holes, and fed through my "blowoff." This cured the burned blowoff pipes and left me in a position to hunt up some more troubles.

About that time a funny thing happened; that is, it seemed funny to me. I afterwards found, though, that it was a very serious thing to these poor souls. We were about to cut in a new boiler—rather one that we had rebuilt—but the men would not give up until it had been "blessed" by the priest. Of course it cost 15 pesos to the priest to have it "blessed," but it was paid, and we set her going. I had a queer feeling for the poor heathen when I saw how they were duped, but as it is a custom of the country, and believing that every man should concede to his neighbor the right to believe as he will, I have tried, to the best of my ability, to take their religious views seriously. A friend told me that while operating the rubber works at the place where he was master mechanic, he one time fired up a new boiler in the night. They were not running nights and the boiler was to have been fired up for the first time the following day, and when the men learned in the morning what had happened, not a man in the whole works would go to work, not that they were angry with him, but they were certain the boiler would blow up sooner or later and kill them all. The works remained dead until a priest had been called and removed the curse, replacing it with his blessing.

In looking over the reports of "washing" boilers, I found all reported as clean, having no scale and in good condition. I'm pretty fat, but I decided to have a "look in" for myself and so started to go through them internally. You'll have to excuse me till I get back.

Correction Note

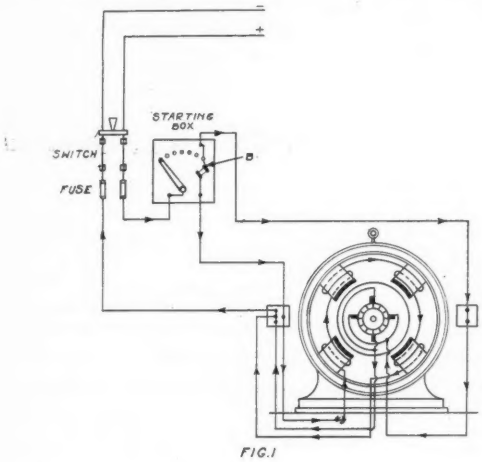
OUR ATTENTION has been directed to the fact that the authorship of the article entitled "Voltage Regulators for A. C. Circuits," which appeared on page 961 of the Oct. 1 issue, should have been credited to James H. Bissland instead of John H. Boynton. The latter is a pen name and was assigned to the article due to misunderstanding between Mr. Bissland and the editor.

THE COMBINED earnings of the Nevada-California Electric Corporation and subsidiary companies, after eliminating inter-company transactions, for the 12 mo. ended Aug. 3, 1921, compare as shown below with the 12 mo. ended Aug. 31, 1920. Surplus includes interest in earned surplus of controlled companies:

	1921	1920
Gross operating earnings	$3,191,227.31	$2,896,643.42
Operating profits	1,699,878.70	1,501,642.28
Interest	769,035.33	702,091.45
Depreciation	272,294.91	213,996.66
Surplus earned	503,252.18	625,603.22

Motor Troubles

A 20-HP. 220 v. direct current motor had for some time given trouble due to its frequent blowing of the fuses, the cause of which seemed to be very difficult to locate, so an electrical engineer was consulted. He advocated the removal of the fuse block with its fuses and replacing them with a circuit breaker. But still the breaker operated too frequently. Investigation brought out that the starter was connected as shown at B, Fig. 1.



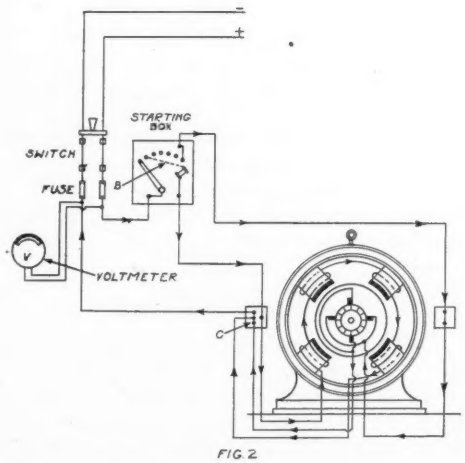


FIG. 1. ORIGINAL CONNECTIONS IN STARTING BOX
FIG. 2. REVISED STARTING BOX CONNECTIONS

Since practically all the line voltage would be absorbed in the starting resistance when the starting box handle would be on the first contact point, the voltage across the field coils would be low, consequently a small amount of current would flow through the field circuits. The field connection was, therefore, changed to that shown at B, Fig. 2. The motor was then tried with the belt off. It started satisfactorily, showing no signs whatever of anything being wrong nor did the starting box get hot. The belt was put on, the motor started and the load applied. In a short time the circuit breaker opened again, shutting down the shop. The motor showed no bad effects and it was evident that the breaker did open due to a short circuit because the motor started right off again. A portable volt meter was secured and the ends of its leads connected across the switch as shown in Fig. 2 and watched for a drop of voltage before the breaker opened, but when the breaker again opened the meter showed the voltage to be perfectly steady, showing that the trouble evidently lay between the switch and the motor. The armature leads were held in brass terminals by set screws. One of these had worked loose, being indicated at C, Fig. 2, which we assumed permitted the circuit to open momentarily at this point due to vibration. Upon tightening this no further trouble was experienced.

In another instance I replaced the motor which had been repaired and attempted to start it, but it wouldn't start, just hum whether loaded or unloaded. After looking over all external connections and finding nothing wrong I concluded that the trouble lay in the magnetically operated switch which was controlled by the water pressure in the tank. So with this idea in mind I pulled out the line or service switch, took down the oil pan of the magnetic switch. This done, I found that both the drum and finger contacts were very badly burned and that one finger contact failed altogether to touch its respective drum contact, and as I had no finger nor drum contacts for renewals with me, I took my hammer and bent all fingers until the contacts were all good, replacing the oil pan and putting on the chain belt, then closing the line switch, the motor started right off instantly until the pressure in the water tank was at its maximum, when it stopped, and likewise when the pressure reached the minimum the motor again started.

J. K. CORLISS.

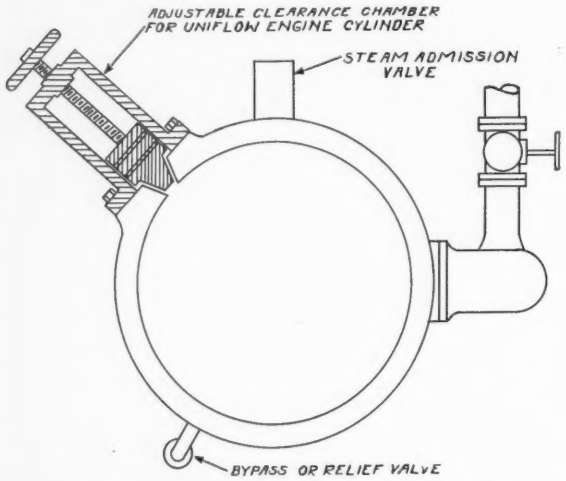
Suggestion for Changing Clearance of Uniflow Engine

WE HAVE in use a uniflow engine, size 17 by 20 in., 225 r.p.m., direct-connected to a 120-kw. generator.

When vacuum drops to about 18 in., automatic bypass valves open up clearance chambers that prevent compression going too high. When the engine is exhausting against close to atmospheric pressure and bypass valves are open, the clearance chambers have the right volume to allow compression up to initial or boiler pressure which is about right; however, when vacuum drops just under the 18 in. and bypass valves open and

with this vacuum and clearance chambers open, the clearance is so excessive that it is not possible to get anything like initial compression or pressure at beginning of stroke, and running under these conditions the engine is what could be called a steam eater and is also very trying on crosshead and connecting rod bearings.

Now, the lower the vacuum drops when bypass valves are open the higher the initial pressure and less steam used; and when vacuum drops to atmospheric pressure, the compression, as before stated, is just about right. If the volume of the clearance chamber could be decreased as vacuum rises or increased as vacuum drops, it then would meet all conditions of exhaust pressure. The majority of refrigerating plants run with higher



SECTION OF CYLINDER SHOWING ADJUSTABLE CLEARANCE CHAMBER

vacuum during the cool season than during the hot season when every machine is run up to capacity.

The proper engine of the uniflow type for the refrigerating plant should be sufficiently flexible that it can run with the same relative economy in steam consumption and also smooth running conditions under varied vacuum as the counterflow condensing engine. The sketch shows the adjustable clearance chamber which I believe will allow proper compression under all conditions.

With the use of the indicator the proper clearance volume for different absolute pressures can easily be determined and this could be suitably sealed on the stem of the clearance chamber piston, and it would be a simple matter to adjust clearance chamber volume to meet operating conditions.

The bypass valves would be set for emergency use only in case of sudden drop in vacuum.

I do not say this idea is new, but I have not heard of its having been tried; however, if it has been tried, I would like to know by whom and with what success.

W. G. MILLER.

Reason for Squeaky Noise

FOR SOME TIME, I had heard a squeaky noise in one of the line shafts in our plant. At first, I thought that one of the shaft bearings was dry or loose, or that one of the shaft couplings was loose and slipping, but in looking them over a number of times nothing was found wrong which possibly could cause the noise. This was a puzzle to me until one day I found the trouble accidentally.

There is a long ¾-in. drain pipe from a large steam pipe near the ceiling of the building and the length of pipe leading down passes close to a line shaft as shown in Fig. 1. In some way, the pipe hanger, B, got loose or broken, when the pipe dropped down and was rubbing against the shaft, causing the noise I had heard and could not locate. The dropping of the pipe placed this in the position illustrated at A, and before it was noticed had worn a groove in the shaft as shown in Fig. 2, and a hole in the drain pipe as shown in Fig. 3.

The shaft and pipe are located in an out-of-the-way place, hence it was not noticed until the drain pipe started to leak and someone wanted to know where the water came from, when an investigation was made, with the above stated results.

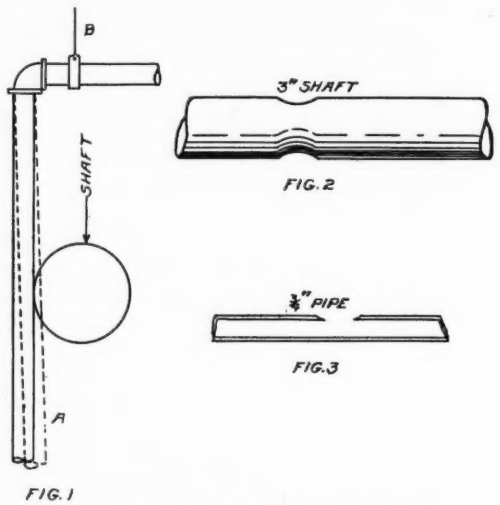


FIG. 1. SHAFT. GRINDING HOLE IN PIPE
FIG. 2. GROOVE WORN IN LINE SHAFT
FIG. 3. HOLE GROUND IN DRAIN PIPE

This experience shows that it is good practice to inspect pipe supports frequently, also to see in what condition they are as they may be loose or nearly rusted through, and as generally is the case, it is the unexpected that gives us trouble. H. A. JAHNKE.

Gas Engine Mishap

WE HAVE a 32-hp. gas engine driving the water supply pump. The engine was not developing the power it used to and we decided to overhaul it. The piston was sent to the city to have the ring grooves made 1/16 in. wider and all of the same width; a set of piston rings came with the piston.

The rest of the engine being then all repaired, the piston was put in the cylinder. The first half hour of running went fine and the load was put on. Before long things turned out differently, the cylinder was getting hot and the piston smoking; the oil supply was increased, especially to the wristpin, which we thought was causing the trouble. The cooling being done by

thermo syphon, nothing could be done to help that part. In a few minutes the engine groaned and knocked, the load was thrown off and the fuel shut off. In a few revolutions the engine stopped, apparently the piston had seized, as it was impossible to turn the flywheels.

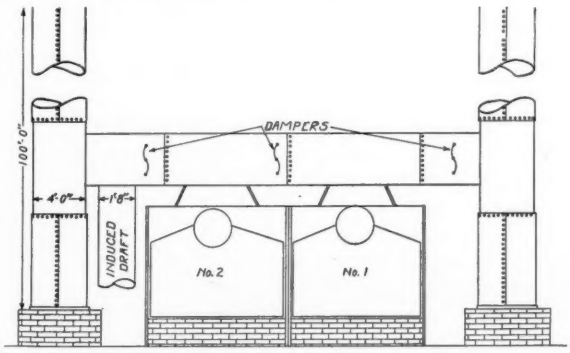
The cylinder was taken off, a mixture of kerosene and oil poured in the cylinder lubricators, and the connecting rod disconnected. By that time, everything (but not everybody) was cooled off. The piston had to be forced out with a small screw jack and we then learned something: the piston rings were too close a fit, the clearance at the gap being insufficient, in expanding with the heat they made things worse; of four rings two were broken in several pieces. Something had to be done, because the water was low; in fact, way below the insurance level mark. To get piston rings of the new size would require three days at least. There were quite a number of old rings and selecting four that looked best, figuring to make two rings to a groove, we traced them to size and hacksawed them in the vise, then laid them on a board and filed each down to size within a couple of thousandths. It took 12 hr. to make them, but they all had a good fit and clearance at the gap. The engine was put together and no more trouble experienced.

If I had taken the rings off the piston and tried each one in the cylinder, I would have seen that there was not enough clearance; but as the piston went in all right, I judged that they must have been right. I once heard that if we knew it all we would not find pleasure in our work; I believe it and plead guilty.

CHAS. LABBE.

Loose Damper Causes Draft Trouble

THE ACCOMPANYING sketch shows two water-tube boilers of the horizontal type, connected to two chimneys from the one breeching. These boilers started giving trouble about 2 yr. ago on account of the draft. When



DAMPER ARRANGEMENT IN BOILER BREECHING

both boilers were operating, the fires in the furnaces would do all that was expected from them; but when one or the other was shut down, there would not be enough draft in the furnace of the working boiler to carry part of the load, which had been light for one boiler in the past. Instead of calling in an engineer who could have solved their problem for them, they installed a fan to supply air to the breeching in an attempt to produce draft for the boiler which was operating whether it was the one nearest the induced air duct or otherwise.

Upon investigation it was found that when the No. 2 boiler was on and the induced fan operating, fairly good results could be obtained. With the No. 1 and middle damper in a closed position, No. 1 boiler would not get enough draft to burn the fuel under any condition when working alone. By shutting the damper and all the front doors on No. 2, there was a noticeable difference in the draft on No. 1. After looking over everything that might have a tendency to defer draft and knowing that the plant had been operating all right up to about 2 yr. ago, I came to the conclusion that there must be something either shut or open between the ash pit and the uptake.

On shutting both boilers down and going through the breeching, it was found that the middle damper had become loose from the rod and caught on the side of the breeching in a wide open position. After tightening this damper and removing the air duct to the breeching, the boilers are doing the same work and are as efficient as they were before this accident happened.

CHAS. J. MILLER.

Common Methods in Which Power Is Wasted

WITH RISING COSTS of operation, waste of power is being seriously studied by all of the large industries. Hardly an issue comes from the power technical press in which this is not discussed in some form—the technical experts employed, the extensive records kept, the proper powering of the different machines, etc.

On the other hand, it is hardly possible that five per cent of the power wasted in this country is done by the large industries, although some of them are pretty bad. The remaining 95 per cent is wasted by the small power user; that is, the man who operates from 1 to 100 hp.

During considerable experience among small power users, it was observed that no matter what form of generating machine was used there was a large majority of installations in which power was wasted. The machines installed were usually much larger than was required.

The following instances were noted near a large city where competent advice would have been available if really sought. The following data is from tests made by the writer.

At an amusement park the owner of a picture concession purchased his electric current from a street railway. The voltage they supplied was 550, while that required to operate the machines was 110 v. The machines were the regular old-fashioned stereoscopes in which a coin is dropped, the lamp lights and one sees the views.

To change the voltage he uses a 4-kw., 550-v. motor belted to 4-kw. 110-v. generator. His bills averaged $40 a mo. at 5c. a kw.-hr. He used 800 kw.-hr. per mo. A test showed that the maximum power that all the lamps could draw was 1 kw. and they averaged 1/3 kw. Running 12 hr. a day, the cost of useful power was $6 a mo. for 120 kw.-hr.; the remainder went to operate the motor generator set. One half kilowatt installation which is large enough could have been operated at less than $10 a mo. The original outfit cost $400 installed.

A month or so later it was noted that a gasoline engine was operating the place. When asked how it worked, he replied, "Fine; my gasoline costs me only $20 a mo. now. It's a little large, but I picked it up cheap." Let us analyze this statement: $20 a mo. at 15c. gasoline represents 133 gal. per mo. At 1/10 gal. per hp.-hr., this represents 1330 hp.-hr., equivalent to 996 kw.-hr. per mo. Useful power from before, 120 kw.-hr. at 1.5c. per hp.-hr., equivalent to 2c. per kw.-hr.; cost 2c. × 120 kw.-hr., or $2.40 per mo. The cost of operating the large engine was the difference, namely $17.60. A 1-hp. engine should have been easily operated for $5 or $6 per mo.

The third example is of a steam engine installation in a machine shop.

The rating of the steam engine was 100 hp. The test showed as follows:

Engine friction loss	7 hp.
Electric generator losses	3 hp.
Shafting and belt losses	19.7 hp.
Power delivered by electric generator	25 hp.
Power drawn from line shafting	6.3 hp.
Total	61 hp.
Useful power	31.3 hp.
Wasted power	29.7 hp.

This is nearly 50 per cent.

There are tens of thousands of such cases throughout the country in rural districts as well as the cities. Practically all large manufacturers of gasoline or gas engines, electric motors and steam engines have competent engineering forces who will furnish advice on the size of engine or motor to purchase if one will give them exact data on the apparatus he wishes to operate. The loss in wasted power goes on continuously and in the course of a year or so amounts to a sum of money which is well worth saving.

A. G. Drury.

Piston Rings and Counterbore

Whether piston rings should run over the counterbore or not appears to be a question that after all the years of running experience is not universally decided. The consensus of opinion is that they should not overrun. The writer remembers an interesting experience some years ago. An old cross-compound Corliss engine was fitted with new cylinders and valve gear for a higher boiler pressure, and on starting up after the alterations a curious "click" was heard in the high-pressure cylinder at the back end just after lead point. The noise continued until three-quarters load was reached, when it became fainter and almost disappeared at full load.

The maker's practice was to make the counterbore so that the rings did not run over, and it was concluded that the rings were too slack to fit in the grooves, but an examination showed that this was not the cause. It was then thought that there had possibly been a draftsman's error in dimensioning the piston ring positions or the counterbore, but an inspection of the drawings showed that they were perfectly correct in this respect.

The noise continued, and remained a mystery until one day the cylinder was opened up to inspect the condition and it was found that the back end ring *did* overrun after all. It appeared on investigation that slight defects in the metal discovered when boring the cylinder had caused the machinist to run the counterbore a little longer to clean up the spongy part, and through some oversight the change had been forgotten, and never recorded on the drawing.

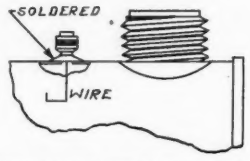
The reason why the "click" was loudest on light loads was fairly obvious. At light loads the exhaust pressure in the high-pressure cylinder was low, and compression was slight; and therefore when admission took place, and the ring was uncovered and exposed to the action of the entering steam there was a quick rise in pressure which suddenly collapsed the ring and forced it against the bottom of the groove. On full load, however, the compression was higher and forced the ring slowly against the bottom of the groove.

The noise was cured very simply by cutting six equally spaced grooves in the back edge of the overrunning ring 1¾ in. long, 3/64 in. deep. These shallow grooves allowed steam to reach the back of the ring, and placed it in equilibrium during its overrunning period.

In the writer's opinion, piston rings should be designed to run within 1/32 in. of the counterbore. Where they have been allowed to run over, the object, of course, has been to prevent the rings wearing a shoulder on the cylinder bore. Charles Hurst.

Oil Can Vent

A vent was needed on a large horizontal oil supply can, as it was necessary to loosen the cap to get the oil to flow out of the cock below readily. The sketch shows how one was made very quickly from a tooth paste tube



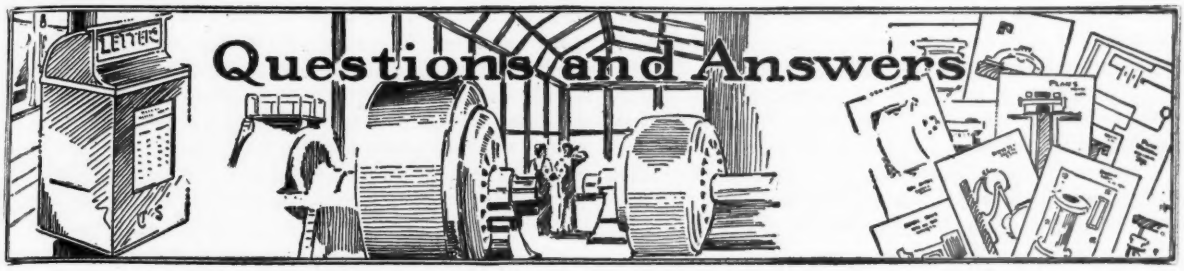
OIL CAN VENT MADE FROM TUBE TOP AND CAP

top. A fine wire was driven into the cap and touched with a warm iron to secure it. This kept the cap from becoming lost and did not interfere with the hole punched in the tank. The edges of the small tapering top were also soldered on. It made a very practical vent as it could be tightened when not in use. The empty tubes are very easy to procure. The idea might be practical to someone else under similar circumstances.

F. W. Bentley, Jr.

In Scotland development of small water powers—50 to 300 hp.—is projected using induction type a.c. generators and all feeding into a network of mains leading to a large town where a steam central station is to be installed. This station will supply the magnetizing current for all the small plants, and as headquarters for distribution, although supply lines may be tapped on at any point of the mains. The small plants will need no attention except periodic visits to look after lubrication and to inspect the machinery.

Copper is showing activity at about 12½ cents.



Is the Boiler Level?

WILL YOU kindly inform me as to how to determine whether or not a horizontal return tubular boiler is pitched? Would you put the spirit level on the brick work or on the safety valve nozzle? E. B. F.

Change in Condenser Design

I HAVE a double-pipe ammonia condenser which I would like to make into an atmospheric type to be placed on the roof to take advantage of the cold weather. Would it be feasible to do this by simply plugging up the inner pipe and letting water fall over the outer pipes in which the ammonia gas is to be condensed? I would like to have the opinion of the readers of Power Plant Engineering as to whether or not this scheme can be worked out. G. G.

Longest High Tension Span

IN REFERENCE to the question on page 927, Sept. 15 issue, "Longest High Tension Span," there is a span 4427 ft. long in the Colgate and Oakland line where it crosses the Carquinez Straits, which is probably the longest line in the United States.

Two steel towers, one 65 ft. and the other 225 ft. high, are required to support the four steel cables that act as conductors across the straits.

S. R. BLAKEMAN.

Welded Stacks

THAT THE welded stack, in regard to which J. J. C., in the Sept. 1, issue, asked for information, has many advantages over the riveted stack, is apparent to all; but one question always arises when the welded stack is discussed: Can it be made as strong as the riveted stack?

The efficiencies of the riveted joints of steel stacks seldom reach 40 per cent except in the large stacks employing double-riveting. It can be seen, therefore, that it is a poor job of welding where the efficiency does not equal that of the riveted joint.

C. O. SANDSTROM.

Safety Valves in Series

IN REPLY to L. S. F.'s question in the Oct. 1 issue as to the pressure at which two safety valves will pop, if the inlet of one valve is connected to the outlet of the other, I would like to say that I saw this stunt tried out 15 yr. ago. I was at an engineers' meeting and this question came up for discussion and quite a lively argument ensued. Finally one of the men present said that if anyone wanted to see it tried out to be at his place of business the following Sunday afternoon, and asked as many to be present as could.

Two 3½-in. valves were borrowed from a neighboring plant that was allowed 25 lb. pressure and was used for heating. These valves were set at exactly 25 lb., then they were connected in a temporary manner to the high-pressure boilers; the inlet of one valve was connected to the discharge of the first and the boiler pressure had to be raised to 50 lb. before the valves would blow.

When two valves are connected in series, the first valve will open at 25 lb.; but as the steam cannot escape to the atmosphere, a pressure is built up between the two valves and this pressure together with the pressure of the spring acting on the disc of the first valve would force it closed, and it was necessary, therefore, to raise the boiler pressure to 50 lb. to get the second valve to operate.

If three valves had been used, the boiler pressure would have had to have been raised to 75 lb. before the third valve would have popped. HARRY H. JOHNSON.

Answers to Examination Questions for First-Class License

IN ANSWER to the questions which appeared on page 879 of the Sept. 1 issue, I submit the following:

To put the spool in the center of the rod of a duplex pump, tighten the set screw in the spool and with a small bar move the rod either way to find which head it stopped against. Either the steam or water piston will be at the far end of the cylinder. Put a pencil mark on the rod, flush with that stuffing-box, then move the rod out of the cylinder until the piston strikes on the other head, and make another mark on the rod, at the same stuffing-box. Find the center between these two marks, and move the rod in the cylinder until this center mark is flush with the stuffing-box. Plumb the rocker arm on this side and place the spool there. It is then in the center of the rod travel.

2. To remove the water piston from the rod, put a draw bar across the end of the rod with holes to match the follower bolts. Use tap bolts through the bar and screw into the follower bolt holes which will draw the piston off the rod. For small pistons, take the head off the steam cylinder, loosen spool on the rod, push the piston against the inner head, and with a hard wood block as a drifting bar against the end of rod, drive it out with a sledge hammer.

3. The "D" slide valve duplex pump has 10 ports, 5 on each side. The two end ports are for admission of steam to the cylinder, the inner ports on each end are to exhaust steam from the cylinder and for compression and the middle port connects to the exhaust pipe.

4. Compression valves on a duplex pump are valves placed in the port passage to the ends of the cylinder, to regulate compression.

5. To change the lead on the American Ball engine without changing any of the moving parts or changing the position of the wheel, it would be necessary to take off some of the lap from the steam edges of the valve itself. With slotted eccentric or overhanging pin inertia governor the lead remains practically the same at all loads.

6. Remove the cylinder relief or drip valve and insert a piece of lead wire with a knob on end to be flattened out and then turn the engine over the center and repeat the operation on the other end. The wire will be flattened to the thickness of the clearance. Replace the drip or relief valves and the engine can then be started in a few minutes.

7. Inclined tubes in water-tube boilers increase circulation by allowing steam bubbles to rise and separate more quickly, and by keeping the tube full of water. The gases from the furnace passing along the inclined tubes have the heat absorbed more freely by the rapid circulation of the water.

8. The tubes of the Heine boiler are placed parallel with the steam and water drum. (b) The water is about 19 in. higher at the back than at the front, i. e., measured on the drum. The water surface is level, and the drum is lower at the back. (c) The middle try cock or half glass represents about 3/5 the volume of the drum.

9. I would put the weld of a welded tube in the rear end of a fire tube boiler so a scraper can be used to keep a greater part of the tube free from soot. Should the weld obstruct the scraper, a steam blower can be used to better advantage.

10. The steam drums of a B. & W. boiler are supported by sling straps surrounding the drums which are bolted up to iron beams over the top.

11. The Heine boiler is supported at the rear by the water leg which rests on the brick setting or iron beam and setting at the front on an iron beam and brick setting which holds the fire door castings at the front end of the boiler.

12. Superheated steam allows greater expansion through many cylinders or stages of turbine with less condensation, before being exhausted, than does saturated steam.

13. The Heine boiler has throat braces to support the flat portion of the heads because a portion of the shell is cut away where the water legs are attached to the drums, while the B. & W. boiler has a reinforcement saddle riveted on the drum to hold the nipples from the headers.

14. The feed water enters the Stirling boiler at the center of the top of the last drum, passes down to a tee with short nipples, discharging both ways into a removable trough, on the back side of the drum, where the water is distributed over its edge.

15. Made of open hearth fire box or extra soft steel, tensile strength 52,000 to 63,000 lb. (b) Extra soft steel, tensile strength 45,000 to 55,000 lb.

16. If the piston packing ring fitted the slot too loosely, I would fit a shim on one side of the ring and rivet it to the ring, or, if the space was very slight, I would put the face side of the ring on a bench block and with a suitable peen hammer, spread the inner diameter by light blows of the hammer near the edge, using care not to hammer the ring out of its true circle, i. e., by expanding it in the wrong direction.

17. If the running boiler pressure was up close to the blowing point of the safety valve, it could not be raised and would not need to be raised.

18. There is danger of water getting into the cylinder of a jet condenser. (b) See that the vacuum breaker is always in working order and cut down on the inlet supply water to the condenser when slowing down or shut the engine exhaust valve to condenser and open the atmospheric relief valve when shutting down.

19. There is little danger of water getting into the cylinder with a surface condenser (b) unless the air pump stopped for a long time and the tubes were leaking badly. The vacuum would be partly lowered and the water of condensation is in small quantity, at the bottom of the condenser chamber and would not be drawn up through the top so quickly.

20. There is much danger of water getting in the cylinder with a syphon condenser (b) because the vacuum tube may be flooded if the foot valve is closed and the condensing water may be drawn up into the exhaust connection.

21. Alternating current generator field windings are rotor wound to dispense with the troubles encountered at the brushes of a stator field wound machine when carrying high voltage and amperage. With field winding on the rotor instead of the stator windings, only a small d.c. passes through the field coils and they can be more securely attached to the rotor.

22. The power factor meter is used to indicate the amount of wattless current being carried on the lines.

R. A. CULTRA.

12. One of the principal advantages of using superheated steam lies in the fact that steam in this condition is entirely dry, approaches, in fact, the state of a perfect gas, and is less subject to initial condensation with its attendant losses. Its special advantage arises from its use in turbines, because with its use there is little if any erosion of the blading such as is the case where saturated steam is used.

17. To obtain the same power from an engine exhausting into the atmosphere as was formerly being obtained, exhausting into a vacuum, the mean effective pressure must be kept the same. Without knowing the original head pressure and the clearance the additional pressure required cannot be determined accurately. The new pressure may be estimated, however, from the empirical relation

$$P = (14.7 + b + m) \times p \div m$$

where P is the new throttle pressure, b is the absolute back pressure in pounds per square inch operating condensing, m is the mean effective pressure and p the original head or throttle pressure.

GEO. B. LONGSTREET.

EDITOR'S NOTE: Question number 17 of this series says: "If you were carrying 28 in. vacuum and lost it, how much would you have to increase the boiler pressure to carry the same load with cutoff at ¼, the same as before losing the vacuum?"

Assuming that the safety valve on the boiler is set at a pressure sufficiently high to allow an appreciable increase in the running pressure, we can find the boiler

pressure required by the following method: First we will assume an engine and the condition under which it operates. Suppose we have an engine of any given bore and stroke running at any given speed and operation between, say, 125 lb. gage or about 140 lb. abs. and a 28-in. vacuum, referred to a 30-in. barometer. Assuming a clearance, say 10 per cent, we can draw a theoretical indicator card for a Rankine cycle with incomplete expansion.

With a planimeter, now, we can find the area of this card, which will be proportional to the mean effective pressure. In order that the engine may be able to do the same work after losing the vacuum as before, it is necessary that the mean effective pressure be the same. It now remains to find a card whose area is the same as that of the first one drawn. Without going into an involved mathematical discussion, this will have to be done by a cut and try method.

We will now increase the throttle pressure by 10 lb., or to 150 lb. abs., draw in the expansion line and find the area, this time excluding that portion below the atmospheric line. After having found the card areas for 150, 160 and 170 lb. head pressure and ¼ cutoff, we plot a curve with pressures as ordinates and card areas as abscissas. Through the point representing the area of the first card we draw a vertical constant volume line. Where this line intersects the curve we find the required throttle pressure, which happens, in this case, to be 163 lb. abs. or about 148 lb. gage.

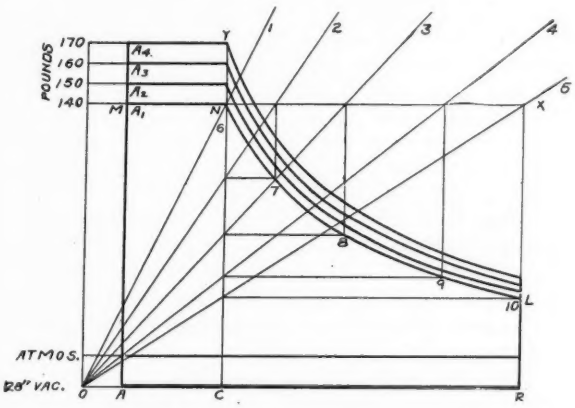


FIG. 1. THEORETICAL RANKINE CYCLE CARD WITH INCOMPLETE EXPANSION

Boiler pressure would have to be more than this by an amount sufficient to allow for the drop in pressure through the steam header. The increase, 23 lb., thus found necessary is not an absolute figure, but one which would vary for different original head pressures as well as back pressures.

The method used in determining this pressure is illustrated in Fig. 1. A-R is the assumed length, O-A is the clearance taken as 10 per cent of A-R. The initial head pressure, 140 lb. abs., M-N represents admission for ¼ of the stroke, N-L is the theoretical expansion line which represents the equation $pv = \text{constant}$. To construct this curve, draw through N, the point of cutoff the horizontal and vertical lines N-X, and C-Y and then from O at zero volume and pressure, a number of diagonal lines 1, 2, 3, 4, and 5 intersecting N-X and C-Y. At the intersections of each diagonal with these lines draw vertical and honizontal lines to intersect at points 6, 7, 8, 9, and 10, which will lie on the desired curve. With a planimeter we find the area of the first card to be 7.20 sq. in., the second, excluding that portion below the atmospheric line, 6.53 A_3 and A_4 are similarly found to be 7.04 and 7.64 sq. in.

It is evident then that the correct head pressure is somewhere between 160 and 170 lb. gage. To find it, we plot pressures against card areas as suggested and

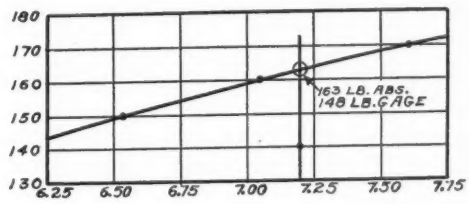


FIG. 2. CURVE SHOWING RELATION BETWEEN HEAD PRESSURE AND CARD AREAS OR MEAN EFFECTIVE PRESSURES

as shown in Fig. 2. From this diagram we find that the line representing the area 7.20 intersects the curve at a pressure of 163 lb. abs. or about 148 lb. gage, which would be the new throttle pressure.

Condensing Water Required

IN THE answer to the question appearing under the above heading in the Sept. 15 issue, page 931, an assumption was made which perhaps was not justified and may cause a misunderstanding among some readers, as it does not conform to ordinary practice. This assumption was that the exhaust pressure was zero, gage, while in ordinary engine operation it is more likely to run around 23 in. vacuum. With the latter assumption, the temperature at condensation would be 146.78 deg. F., but the hot well temperature with a jet condenser ordinarily runs from 20 to 30 deg. below this, or say 25 deg. This makes T_2 of Kent's formula previously given equal to 146.78 — 25 or 121.78 deg. Substituting in the formula given for jet condensers we have the weight of condensing water per pound of steam is,

$$Q = (1114 + 0.3 \times 229.5 - 121.78) \div (121.78 - 84)$$
$$= 28 + \text{lb.}$$

In ordinary power plant practice, this ratio ranges from 20 to 40. EDITOR.

Engine Speed

FOR ORDINARY duty, how many revolutions per minute should a 150-hp. single Corliss engine make, and why? C. E. R.

A. The speed of an engine is usually designed from the allowable piston speed, or rather the r.p.m., is usually a given quantity from which to work and is determined by the service which the engine is to perform. The cylinder dimensions are determined from that and the allowable piston speed, which for ordinary duty may be taken at from 800 to 1000 ft. per min. For very large engines, this figure should be reduced and for light engines, may be increased somewhat. For an engine already built the speed may be determined from the relation $2 \times L \times \text{r.p.m.} = \text{piston speed}$, from which $\text{r.p.m.} = \text{P.S.} \div 2L$, where L = length of stroke in feet.

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Graphic Solutions

Growth in engineering knowledge is due largely t careful observation in the operation of machinery an experimenting along new lines or beyond the limits o former practice or knowledge. Then the experimente formulates laws, frequently in the form of mathematica equations, to which the changes in conditions of th materials with which he is dealing conform.

Quite frequently the mathematics involved in th solution of many engineering problems are well nigh impossible of solution except by those highly trained, which has led others to the use of doubtful rules of thumb, and even the best of engineers will sometimes pass up an accurate formula for one that is approximate when time for making estimates is limited and the accurate formula is difficult to solve.

Such conditions as the above lead engineers to calculate many extensive tables for their every day use, and many of these will be found in reference hand books of today. There can be no more accurate data than such tables carefully computed from accurate formulas, but these tables are not always available when quick solutions are required. One of the first answers to this problem was the slide rule, which, in the hands of a careful engineer, will give results within 1 per cent of absolute accuracy.

Many problems in engineering, however, are based on experimental data and the formulas do not lend themselves readily to solution by a slide rule. In such cases, careful constructed charts will serve to give solutions sufficiently accurate for almost any engineering problem. During the past few years wonderful progress has been made in the construction of various kinds of charts until today nearly any mathematical formula can be worked up into the form of a chart in remarkably short time compared with the time required for calculating a table for the same purpose.

Aside from the speed with which problems can be calculated on charts, a conception is given of the relative importance in the results obtained of different changes in conditions of the problems which is of great importance to the engineer in making preliminary calculations.

On other pages of this issue, Paul F. Christopher gives a striking example of the use of a graphic method of estimating the heat in the exhaust steam from a turbine at various loads. His method involves the use of the heat-entropy diagram for steam and a specially constructed diagram, both of which can be readily used without difficult mathematical calculations. It behooves every engineer to acquaint himself with such time-saving, calculating methods.

Lightning Protective Equipment

Ever since the day Benjamin Franklin, by means of his famous kite experiment, demonstrated to the world that lightning was electrical in its nature, men have busied themselves inventing devices which would minimize or prevent the destructive effects of the thunder bolt. The first of these, of course, was the lightning rod, a device as simple in construction as its use is universal.

The lightning rod was the forerunner of the lightning arrester, a device without which no outdoor electric cir-

cuit is complete today. Primarily intended to protect the circuit from damage due to lightning discharges, either direct or induced, its scope has been extended to take care of internal disturbances in the circuit as well. Its development has kept pace with development in other branches of the electrical art and from the simple spark gap or carbon rod of days gone by it is today an intricate device, the design of which is based on sound engineering principles and the performance of which can be predetermined for any given set of conditions.

The importance of lightning arresters as a part of modern electrical installations can hardly be underestimated. In selecting an arrester for any particular installation, the protective investment should not only be governed by the value of the apparatus it is necessary to protect, but also by the loss of revenue which may be occasioned by an accidental shutdown due to lightning or similar disturbance. In fact, the selection of proper lightning protective equipment is one which involves a number of technical and commercial considerations, a knowledge of which is essential if the maximum amount of protection is desired.

In order to provide the average power plant engineer with a standard on which to base his judgment when he is confronted with the problem of selecting new protective equipment, V. E. Johnson has prepared an article, in which he discusses in detail the various considerations which govern the proper selection of this type of equipment. This article which appears in the current issue, will, it is hoped, give the engineer a better insight into the operating characteristics of lightning arresters and allied equipment.

Off Duty

Within the past year, there issued from the research laboratory of the General Electric Co. at Schenectady an announcement which, if the births of scientific achievements were announced in the manner that human births are, might have read something like this: "Born, 1921, at Schenectady, Mag Ne Tron, son of the Tron family. Brother of Ken O. Tron, Pli O. Tron and Dyna Tron."

Those of you who are acquainted with the other members of the Tron family, more commonly known as the electron tube family, will no doubt be able to predict Magnetron's characteristics, or rather, his purpose in life at once by merely analyzing his name.

As Lee De Forest humorously puts it, "Magnetron" is a Greeko-Schenectady name for a vacuum electric device which is controlled by a magnetic field. According to Albert W. Hull, in a lecture before the A. I. E. E., the Magnetron consists essentially of a cylindrical tube, containing a straight tungsten filament surrounded by a cylindrical anode. Around the outside of this glass tube is wound a solenoidal coil for the purpose of setting up a magnetic field parallel to the axis of the tube. The tungsten filament is so placed as to form the common axis of the cylindrical anode, the tube, and the solenoid. So much for its construction.

Electrically, the Magnetron is a valve, operated by a magnetic field. It can be made to open or close the circuit of which it forms a part, in the same manner that a valve in a steam, water, or air line will cut off or start the flow according to whether it is closed or open. If a constant voltage is impressed between the tungsten filament and the cylindrical anode, a current will flow across the intervening space. This current is not affected by a magnetic field below a certain critical value, but falls to zero if the magnetic field is increased beyond that value. In operation the tungsten filament is heated to incandescence by a separate battery.

It is obvious, then, that the current flowing through the tube may be controlled by the magnetic field, just as a comparatively strong current may be controlled by a weak current through the agency of a relay. And that's just what the Magnetron is, a relay—an almost inertialess relay. The mechanical relay usually has an iron armature, which when attracted by a magnet closes an electric circuit. In the Magnetron, the moving parts are electrons. These electrons are shot out from the hot tungsten wire to the cylindrical anode. Each minute electron carries a charge. It is the sum total of all the tiny charges of the individual electrons which traverse the vacuum between the filament and the anode that constitute the electric current. The electrons emitted in this manner are extremely numerous. The current which courses through a 16-c.p. lamp every second, for instance, requires the passage of so vast a number of electrons that if 2,500,000 people (approximately the population of Chicago) were to start counting them at the rate of two per second, neither taking time to eat, sleep nor die, it would take them 20,000 yr. to complete their task.

If, however, the magnetic field is sufficiently strong the electrons are prevented from ever reaching the cylindrical anode. Before they reach the anode, they are deflected by the magnetic field, and their former straight path transformed into a curved one around the tungsten filament. The electrons thus being unable to transfer their charges to the anode, the current through the tube is cut off as a consequence.

The foregoing is, of course, an exceedingly elementary explanation of this new device, but it is hoped will serve to illustrate the principle upon which it operates. Although the youngest member of the electron tube family, it already predicts for itself a great future.

"In 5 yr.," said Dr. Hull, "you will see the Magnetron in substations replacing synchronous converters. In 10 yr. they will be on electric locomotives, either as rectifiers, allowing the use of d.c. motors, or as variable frequency alternators. Twenty years will see d.c. transmission lines fed through transformers and kenotrons, at convenient points, by alternators of any frequency, and tapped by the same tubes acting as Magnetron alternators. The power capacity of these tubes is ample for this purpose. Electron devices are not small inherently, they are only young."

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Faber Blowoff Valves Redesigned

THE FABER blowoff valve as manufactured by Elliott Co. has recently been re-designed and some new features added. It will be remembered that the distinctive feature of the Faber blowoff valve, which is still retained, is that steam or pure water is piped to a connection in the side of the valve so that as the valve is being closed, after the water from the boiler is practically shut off, the seat and disc are cleansed by the steam jet before coming in contact with each other, preventing scoring, the principal cause of leakage in blowoff valves.

Another trouble, however, which has been experienced with blowoff valves of the plug or piston type, is the accumulation of scale and sediment on the top of the piston which, after a time, might prevent the valve from being opened to full capacity. In the redesigned

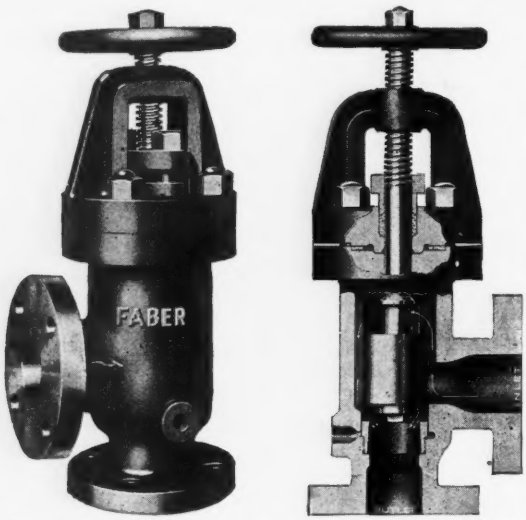

FIG. 1. EXTERIOR VIEW OF FABER BLOWOFF VALVE
FIG. 2. SECTIONAL VIEW SHOWING COURSE OF CLEANSING STREAMS

blowoff valve, this difficulty is eliminated, for as the valve is opened, a circulation of water is set up around and over the top of the piston, through channels in the valve body, thoroughly cleansing the top of the piston in the act of opening the valve. The sectional illustration shows the circulation of the water over the top of the piston, as the valve is being opened. When the valve is closed a little farther down than shown in the illustration, water from the boiler is practically shut off, and the steam entering through the ½-in. opening shown at the left cleanses the valve seat and disc of sediment just before the valve is finally seated.

New Type Belt Driven Air Compressor

BELT driven air compressors, the design of which has incorporated in it several noteworthy features of construction, including Ingersoll-Rand plate valves, for both the air intake and discharge, and the 5-step clearance control for regulating the compressor's output, have just been put upon the market by the Ingersoll-Rand Co.

The most important feature of the plate valves used in this type of compressor is that the valve is supported throughout its entire operation in alinement without any form of wearing guide. The clearance control is a method of securing extremely efficient operation at partial loads. Under average working conditions, the demand for air is seldom steady throughout the working day and for this reason the performance of the compressor at underload is of primary importance.

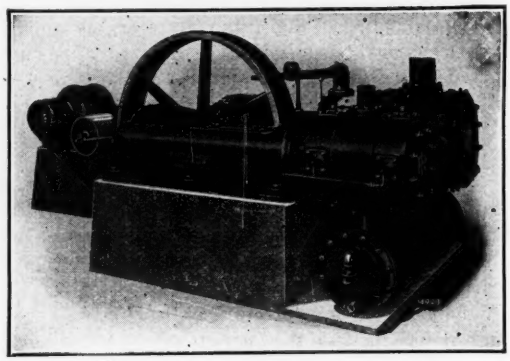

FIG. 1. NEW TYPE AIR COMPRESSOR WITH SHORT BELT DRIVE

With the clearance control, the compressor is automatically loaded or unloaded in five successive steps, these steps being obtained by the reduction or addition of clearance space to the air cylinders. The compressor will operate at full, ¾, ½, ¼ and no loads and the design of the clearance control is such as to secure efficient operation at any one step, the reduction in input power required being practically in proportion to the reduction in output capacity. The entire control is

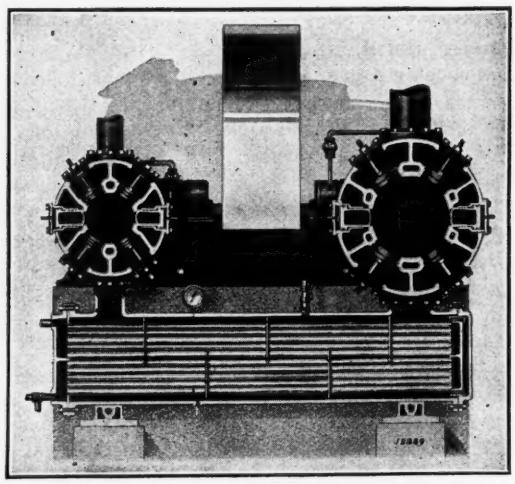

FIG. 2. SECTION THROUGH CYLINDERS AND INTERCOOLER OF NEW TYPE AIR COMPRESSOR

automatic. The clearance pockets are made integral parts of the compressor cylinder and the entire regulation is obtained by the control of the volume of air taken in and compressed.

With this method of control there is no loss of power due to wastage of air and leakage. The clearance pockets in the cylinder are automatically thrown in communication with the ends of each cylinder in proper suc-

cession, the process being controlled by a predetermined variation in receiver pressure. With the compressor operating at partial capacity a portion of the air is compressed in an added clearance space instead of passing through the discharge valves. On the return stroke, this air expands, giving up its stored energy to the pistons.

The inlet valves remain closed until the cylinder pressure equals the intake pressure. At this point the inlet valves are opened automatically and free air is taken into the cylinder for the remainder of the return stroke. Thus the inlet capacity is reduced without reducing the intake pressure. On a two-stage compressor, clearance space in proper proportion is added simultaneously for both high and low cylinders, giving a constant ratio of compression and maintaining conditions necessary for the highest compression efficiency throughout the entire load range.

Another added feature of this control is the maximum demand stop which will prevent the compressor being operated at any higher maximum load than is desired. This can be adjusted so that the compressor will operate on a maximum of ¼, ½, ¾, or full load and, under conditions where the load factor is comparatively low, it is of value in reducing the maximum demand, permitting a saving in the purchase of electric power.

With the clearance control, reduction in power required will be in proportion to reduction in output capacity. All the mechanism for regulating the compressor is independent of the compressor running gear. The loading and unloading of the compressor is automatically accomplished in steps, the difference between any two steps being small enough to prevent any undue electric current fluctuation.

News Notes

THE TWELFTH annual convention of the National Association of Practical Refrigerating Engineers will be held at Hotel Lorraine, Philadelphia, Pa., on Nov. 30, and Dec. 1, 2 and 3, 1921. This is the first meeting of the association to be held in the east.

The program to be provided will include papers by men of world-wide reputation, who are being chosen because of their familiarity with the particular subjects in which the membership, and refrigerating engineers in general, are interested. Also, there will be papers of interest to all groups of the refrigerating industry, including the employers and managers who will be welcome to attend as visitors.

The educational and examining board of the National Association of Practical Refrigerating Engineers has recently had prepared under its supervision a lecture course on "The Principles of Refrigeration," in 20 parts, for the benefit of its members. Starting with lecture No. 1, the course is sent to them at intervals of two weeks. Any further information regarding the lecture course or the convention may be had from the national secretary, Edward H. Fox, 5707 West Lake St., Chicago.

THE ELECTION of Mortimer Elwyn Cooley, dean of the College of Engineering and Architecture of the University of Michigan, as president of the American Engineering Council of the Federated American Engineering Societies was announced at a meeting of the executive board of the council, held at the Cosmos Club in Washington on Sept. 30. Dean Cooley assumes office at once and will carry out an extensive program in the interest of the public and the profession of engineering.

OWING TO the growth of business in China, the Westinghouse Electric International Co. has opened an office in Shanghai. This office will have eventually several branches throughout the country in order to handle adequately inquiries and negotiations for electrical equipment. J. D. Birrell, who has long been engaged in business in the Far East, is the manager of the new office.

AMERICAN STEEL & WIRE Co. has recently appointed E. E. Aldous as representative in St. Paul, Minneapolis, Duluth territory, with headquarters at St. Paul. Mr. Aldous has been connected with this company for 20 yr. in different positions and is well posted in the different lines handled.

HOMER W. SCOTT is now in charge of the Cleveland office of the Jeffrey Manufacturing Co., located at 437 Leader News Building, and C. R. Heller is now in charge of the Buffalo office located at 1108 Marine Trust Building.

C. E. WHITE, former sales manager of the Sterling Manufacturing Co., of Cleveland, Ohio, has been appointed sales manager of the Fulton Co., Knoxville, Tenn.

IN THE item on page 1032 of the Oct. 15 issue, relative to equipment furnished the Chilean State Railroad, the list should have included six express locomotives. All of the locomotives furnished this railroad are of Baldwin-Westinghouse manufacture.

Books and Catalogs

STEAM BOILERS, by Terrell Croft; 412 pages, 5½ by 8, 514 illustrations, cloth; New York, 1921.

Croft takes up in this book the subject of steam boilers as regards their function, evolution, types, codes governing their construction and operation, materials used, structural details, accessories, firing and management and finally their proper selection to meet various requirements. He starts in with a brief history and carries the development through to the modern designs. The material is clearly, concisely and interestingly handled and the result is a book that can be easily read and understood by anyone having only a rudimentary knowledge of mathematics.

At the end of each division or chapter is a set of questions covering the material in that division and in some cases there are problems to be solved. This method of handling makes the book especially adapted to the needs of anyone preparing to pass an engineers' license examination.

The work is bountifully illustrated with drawings so prepared as to convey the maximum desired information with a minimum of explanatory discussion.

WHEELER CONDENSERS is the title of the new General Catalog issued by the Wheeler Condenser & Engineering Co., Carteret, N. J., which illustrates and describes a complete line of condensers and accessories for stationary and marine service. Many of the designs described are of special interest to power plant engineers, since they represent most recent engineering improvement. Among them are: a new design of a 26-in. vacuum surface condensing equipment adapted for engine work and dispens-

ing with combined auxiliary pumps; the Wheeler steam jet air pump with combined inter-condenser and heater operating at maximum efficiency without complicated and expensive accessories; the Wheeler jet condenser with expansion joint between condenser body and a turbine and a centrifugal removal pump having a special vertically split casing. In a section devoted to Crescent brand condenser tubes, the precision that enters into each step of the manufacture of the highest quality tubes is explained.

BULLETINS N-1 and N-2, just published by Elliott Co., Jeannette, Pa., are both descriptive of the Elliott deaeration process for the removal of air and dissolved gases from water in order to prevent corrosion. Bulletin N-1 is devoted especially to the application of this process to power plant work, while Bulletin N-2 treats more especially of its application to domestic hot water service.

These bulletins will be sent out upon request to anyone interested.

VARIOUS TYPES of radiator valves made by The Ohio Brass Co., Mansfield, Ohio, are illustrated in a folder lately received.

POLYPHASE INDUCTION MOTORS, continuous rated, squirrel-cage, riveted steel frame type, are the subject of Bulletin 1118 of Allis-Chalmers Mfg. Co., Milwaukee, Wis.

HUNT CUTOFF VALVES for coal, ashes, coke, ore, stone, sand, gravel, cement clinker, etc., are illustrated and described in Catalog No. 21-1 from C. W. Hunt Co., Inc., West New Brighton, N. Y.

"CONCRETE BINS and Pits for Coal Storage," a pamphlet published by Portland Cement Association, discusses methods, effects, etc., of storage and illustrates various types of storage structures.

BULLETINS were lately received from Nash Engineering Co., South Norwalk, Conn., as follows:

Bulletin No. 16, on "Jennings Hytor Condensation Pumps," motor driven centrifugal pumps designed to handle condensate from steam heating or drying systems.

Bulletin No. 17, "Jennings Hytor Air Line Vacuum Heating Pumps, Electric Motor Driven," which may be used on any service to exhaust air or non-corrosive gases when the vacuum required will not exceed 20 in. of mercury.

A NEW BULLETIN, E-10, published by the M. J. Dougherty Co. of Philadelphia, has interesting comments on the importance of the piping system and the value of proper design and erection. In brief concise language easily understood by anyone, it gives the busy executive a comprehensive outline of the essentials of modern piping practice.

THE HADFIELD-PENFIELD STEEL CO., Bucyrus, Ohio, has issued two catalogs describing and illustrating its Diesel type horizontal and vertical standard fuel oil engines. The engines are built on the two-cycle principle with a crosshead which also serves as a pumping piston for furnishing air to clean out and fill the main working cylinder.

The horizontal engine is built in three sizes of cylinders and of 50, 75 and 100 b.hp., the last two sizes being built as twin units, giving 150 and 200 b.hp. The vertical engine is built in two cylinder sizes, 50 and 125 b.hp. per cylinder, and in from two to six cylinder units.

The catalogs give much interesting detail as to construction of the engines and economy to be obtained by using them.

BULLETIN No. 232, "The Variety of Furnace Design," from W. S. Rockwell Co., 50 Church St., New York, is the third of a series dealing with fundamentals that influence the quality and cost of heated products. It illustrates the relation of type and arrangement of heating equipment to cost of production, and the many factors that must be considered in adapting such equipment to individual manufacturing conditions.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for October 1, 1921.

State of Illinois
County of Cook
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, none.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
A. E. Rice, Wilmette, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in case where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has an interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 24th day of September, 1921. Ella O. Klein.

(SEAL) (My commission expires April 9, 1923.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.